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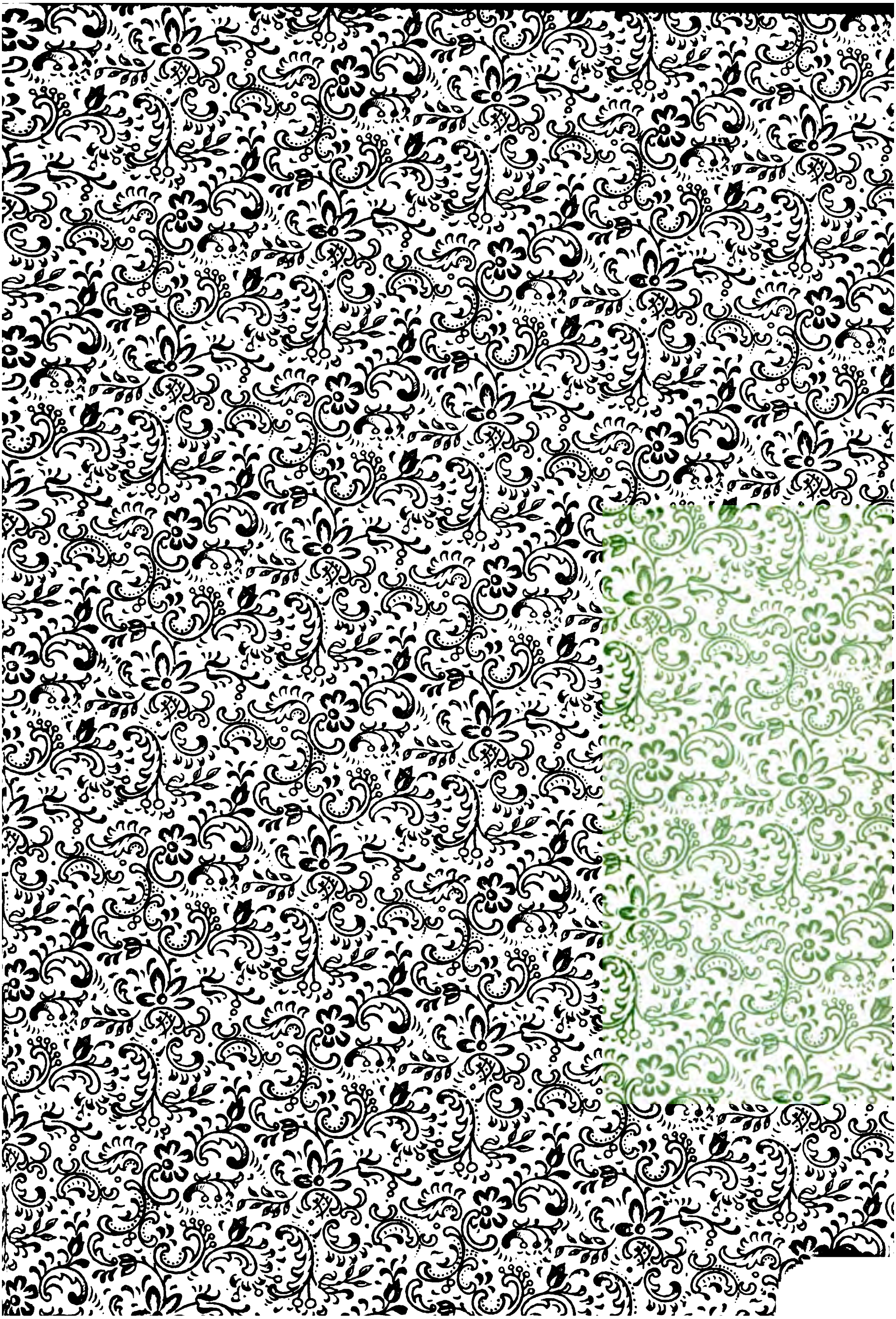

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# PREFACE

Usually the separate subjects covered by the term "navigation and nautical astronomy" are too roughly generalized for one to readily understand, the result being a constantly increasing demand for a special work for the use of those wishing to study navigation with the intention of obtaining a U. S. Local Inspectors license.

The selection and arrangement of the various methods and explanations in detail of keeping track of a ship by "dead reckoning" or "account," including Mercator and middle latitude sailings, and use of logarithms are not written from theory alone, but from actual practice, and several years' experience as a nautical instructor, which makes possible the production of this volume for the beginner.

The matter in this volume is arranged in the proper order for study and should not be deviated from as the nature of the problems in the last part is such that they cannot be managed by those without that knowledge contained in the first part. For that reason it is suggested that the usual custom of beginning study in spots in the advanced portion of a book should not be followed.

Bowditch tables have been used throughout and those are referred to where table numbers are mentioned.

R. M. PUGSLEY.

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## EXPLANATION

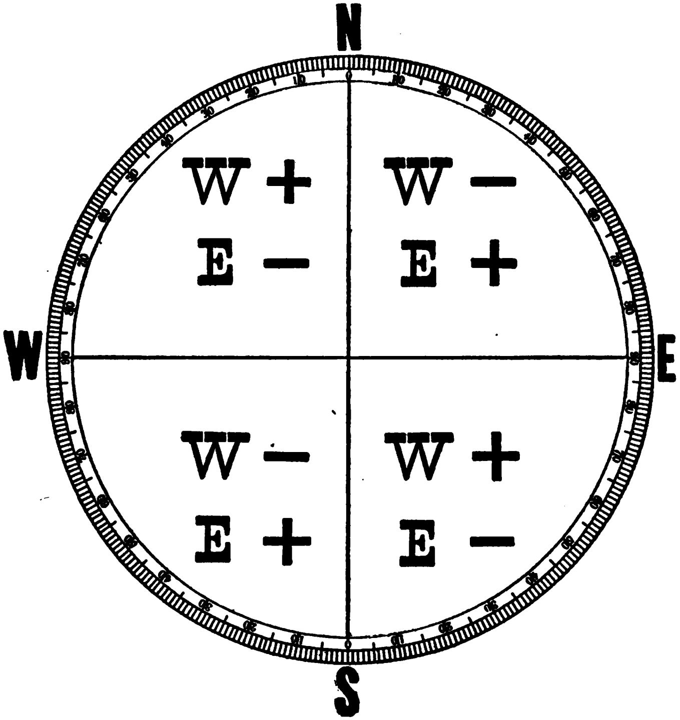
When the compass course is between north and west, it is in the north-west quadrant, the signs indicating that the variation, deviation or compass error, if west, are to be added to the compass course. If east, they are subtractive.

When the compass course is between south and west, it is in the south-west quadrant, the signs indicating that the variation, deviation or compass error, if west, are to be subtracted from the compass course. If east, they are additive.

When the compass course is between south and east, it is in the south-east quadrant, the signs indicating that the variation, deviation or compass error, if west, are to be added to the compass course. If east, they are subtractive.

When the compass course is between north and east, it is in the north-east quadrant, the signs indicating that the variation, deviation or compass error, if west, are to be subtracted from the compass course. If east, they are additive.

The result in any case will be the true course.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## MATHEMATICAL SIGNS

+ **Plus.** The sign of addition: indicates that the quantity is to be added, as

| | | | |
|---|---|---|---|
| Lat. left | 27° 09′ 25″ N. | Long. left | 68° 53′ 45″ W. |
| Dif. | + 2 53 45 N. | Dif. | + 2 17 45 W. |
| Lat. ship | 30 03 10 N. | Long. ship | 71 11 30 W. |

— **Minus.** The sign of subtraction: indicates that the quantity is to be subtracted, as

| | | | |
|---|---|---|---|
| Lat. left. | 38° 16′ 15″ S. | Long. left | 35° 22′ 15″ E. |
| Lat. ship | — 32 28 30 S. | Long. ship | — 33 46 45 E. |
| Dif. | 5 47 45 N. | Dif. | 1 35 30 W. |

× **Multiply.** The sign of multiplication: indicates that the quantities are to be multiplied, as

| | |
|---|---|
| Hourly drift of a current 1¾ mile | = 1′.75 |
| Throughout the day | = × 24h |
| | 700 |
| | 350 |
| Drift in one day | = 42′.00 |

and

$$\begin{array}{lrrr} & 7^\circ & 42' & 45'' \\ & & \times & 2 \\ \hline \textit{Ans.} & 15 & 25 & 30 \end{array} \qquad \begin{array}{lrrr} & 8^\circ & 22' & 31'' \\ & & \times & 3 \\ \hline \textit{Ans.} & 25 & 07 & 33 \end{array}$$

÷ **Divide.** The sign of division: indicates that the quantity is to be divided, as 63° 15′ 30″ ÷ 2, and is usually written thus:

$$\frac{63^\circ\ 15'\ 30''}{2} \qquad \begin{array}{lr} & 2\overline{)63^\circ\ 15'\ 30''} \\ \textit{Ans.} & 31\ \ 37\ \ 45 \end{array}$$

= **Equality.** The sign of equality: indicates that the quantities between which it is placed are equal, as in latitude 30°, departure 60′ = difference of longitude 120′.

. **Decimal point.** The sign indicating by its position the value of a number, as

151. is one hundred and fifty one.
15.1 is fifteen and one-tenth.
1.51 is one and fifty-one hundredths.
.151 is one hundred and fifty-one thousandths.

## DECIMALS

Of all the mathematical signs indicating operation or value, the decimal point is the most important, and is given the least consideration by many who study navigation and nautical astronomy. For that reason it is suggested that the student should not begin advanced work until the use of the decimal point is thoroughly known and practised.

A decimal is a fraction having some power of ten for its denominator which is not used, the value being fixed by the location of the decimal point.

Ciphers to the right of a decimal does not change its value; but between the decimal point and the figures, it does.

## ADDITION

The addition of decimally expressed quantities is the same as whole numbers, if they are so placed that the decimal points, including that of the sum, are directly under the one uppermost.

Examples: Add

| | | | |
|---|---|---|---|
| | 45.63 | | 10.11 |
| | 90.43 | | .151 |
| | 1.015 | | 10.3 |
| | 181.9 | | 1.821 |
| *Ans.* | 318.975 | *Ans.* | 22.382 |

## SUBTRACTION

The subtraction of one decimally expressed quantity from another is the same as whole numbers if they are so placed that the decimal points, including that of the remainder, are directly under the one uppermost.

In teaching subtraction, it is customary to place the smaller number under the greater. That cannot be adhered to in this work, as they must occupy a proper position.

Examples: Subtract

$$\begin{array}{lr} & -\ 273.54 \\ & 9321.4306 \\ \hline \textit{Ans.} & 9047.8906 \end{array} \qquad \begin{array}{lr} & 8328.469 \\ & -\ 869.783 \\ \hline \textit{Ans.} & 7458.686 \end{array}$$

## MULTIPLICATION

The multiplication of quantities expressed decimally is the same as whole numbers, except that the product must contain consideration. If the product does not contain a sufficient consideration, and if the product does not contain a sufficient number of figures place the proper number of ciphers to the left.

Examples: Multiply

$$\begin{array}{lr} & 58''.68 \\ & \times\ 7.35 \\ \hline & 29340 \\ & 17604\phantom{0} \\ & 41076\phantom{00} \\ \hline \textit{Ans.} & 431.2980 \end{array} \qquad \begin{array}{lr} & 3.75 \\ & \times\ 16.5 \\ \hline & 1875 \\ & 2250\phantom{0} \\ & 375\phantom{00} \\ \hline \textit{Ans.} & 61.875 \end{array}$$

## DIVISION

If the divisor contains decimals, the decimal point in the dividend must be moved to the right as many places as there are decimals in the divisor. Then divide as if a whole number.

Examples:

```
58.68)431.29,8(7.35 Ans.
      41076
      -----
       20538
       17604
       -----
        29340
        29340
        -----
```

```
3.75)61.87,5(16.5 Ans.
     375
     ----
     2437
     2250
     ----
      1875
      1875
      ----
```

## THE USE OF COMMON LOGARITHMS

When numbers are to be multiplied or divided, logarithms may be advantageously used, as by doing so those operations are performed by simple addition or subtraction and are essential in the practice of navigation.

The logarithm is composed of two parts: the index and the decimal portion. The index is fixed by the number of figures composing the number for which the logarithm is wanted. The decimal part is found in Table 42.

The index is one less than the number of figures to the left of the decimal point.

| | | | |
|---|---|---|---|
| 4563. | index is | 3. | .65925 |
| 456.3 | " " | 2. | |
| 45.63 | " " | 1. | |
| 4.563 | " " | 0. | |

To take a logarithm from Table 42, find the first three figures in the first column and the fourth figure at either the top or bottom and the proper logarithm will be found at the intersection. When using this table, bear in mind that the numbers 1, 2, 3, 4, 5, etc., at the top and bottom of the table are not tenths. They are the fourth figures. The logarithm for a decimal is found in the same manner.

If the number is a decimal without ciphers between the decimal point and the first figure, the index is 9. If there are ciphers between the decimal point and the first figure, subtract 1 from 9 for each cipher to obtain the index, as

$$\left.\begin{array}{lll} .4563 & \text{index is} & 9. \\ .04563 & \text{``} \quad \text{``} & 8. \\ .004563 & \text{``} \quad \text{``} & 7. \end{array}\right\} .65925$$

but the decimal part from Table 42 remains the same.

## MULTIPLICATION

To multiply one number by another, select the logarithms from Table 42, and when properly indexed their sum will be the logarithm of the product. This logarithm, when found in Table 42, will be at the intersection of some figures in the first column and under one of the numbers at the top of the page. These four figures pointed off from the right, so there will be one more than the index, will be the product wanted.

Example: Multiply 203.4 by 3.

| | | | | |
|---|---|---|---|---|
| | 203.4 | index 2.30835 | | 203.4 |
| | 3. | " + 0.47712 | | × 3 |
| *Ans.* | 610.2 | = 2.78547 | *Proof* | 610.2 |

Example: Multiply .73 by 2.7.

| | | | | |
|---|---|---|---|---|
| | | | | .73 |
| | .73 | index 9,86332 | | × 2.7 |
| | 2.7 | " + 0.43136 | | 511 |
| *Ans.* | 1.971 | = 0.29468 | | 146 |
| | | | *Proof* | 1.971 |

Example: Multiply 92 by 8 and the product by 6.

| | | | | |
|---|---|---|---|---|
| | | | | 92 |
| | 92. | index 1.96379 | | × 8 |
| | 8. | " 0.90309 | | 736 |
| | 6. | " + 0.77815 | | × 6 |
| *Ans.* | 4416. | = 3.64503 | *Proof* | 4416 |

## DIVISION

To divide one number by another, select the logarithms from Table 42 and when properly indexed, subtract the logarithm of the divisor from that of the dividend, adding 10 to the index of the logarithm of the dividend if necessary to make subtraction possible, and the remainder will be the logarithm of the quotient.

Example: Divide 20.01 by 8.7.

| | | | |
|---|---|---|---|
| | 20.01 | index 1.30125 | 8.7)20.0,1(2.3 *Proof* |
| | 8.7 | " −0.93952 | 174 |
| *Ans.* | 2.300 | = 0.36173 | 261 |
| | | | 261 |

Example: Divide 7 by 8.

| | | | |
|---|---|---|---|
| | 7. | index + 10 = 10.84510 | .8)7.(.875 *Proof* |
| | 8. | " − 0.90309 | 64 |
| *Ans.* | .875 | = 9.94201 | 60 |
| | | | 56 |
| | | | 40 |
| | | | 40 |

## LOGARITHMS FROM TABLE 44

For the solution of many problems in navigation the use of logarithms from Table 44 is necessary and should be thoroughly understood. In this work they are used in the sailings.

The degrees begin at the top of the page and run to the right to 45°. From that they run on the bottom to the left to 90° and then on the bottom to the right to 134°. From 135° to 180° they run to the left at the top of the pages. The degree of the angle being located at one side or the other of the page, the miles must be taken from the mile column on the same side. If the degrees are found at the top, the various names must also be read from there and when the degrees are at the bottom of the page the names over the columns must be read from the bottom.

If the logarithm wanted is to be corrected for seconds, the logarithm for the lesser mile is taken and then find the seconds in the left-hand mile column. The correction will be found opposite in the column of differences next to that from which the loragithm is taken and is added or subtracted, according to the next logarithm being more or less.

Up to and including 4° and other angles on the same pages, the correction columns contain the difference for 1′. When the angle falls on those pages, the correction for seconds is found by taking the number directly opposite, dividing it by 60 and then multiply by the number of seconds or reduce the seconds to a decimal part of a mile and by it multiply the number from the correction column. The logarithm is taken for the nearest mile when a correction column is not given.

1. Example: Find the logarithm sine for $35^\circ\ 25'\ 28''$.

| | | |
|---|---|---|
| $35^\circ\ 25'$ | sin. | 9.76307 |
| $28''$ | cor. | + 8 |
| $35^\circ\ 25'\ 28''$ | = sin. | 9.76315 |

2. Example: Find the logarithm cosine for $125^\circ\ 54'\ 42''$.

| | | |
|---|---|---|
| $125^\circ\ 54'$ | cos. | 9.76817 |
| $42''$ | cor. | + 12 |
| $125^\circ\ 54'\ 42''$ | = cos. | 9.76829 |

3. Example: Find the logarithm cosine for $144^\circ\ 00'\ 50''$.

| | | |
|---|---|---|
| $144^\circ\ 00'$ | cos. | 9.90796 |
| $50''$ | cor. | + 8 |
| $144^\circ\ 00'\ 50''$ | = cos. | 9.90804 |

4. Example: Find the logarithm tangent for $54^\circ\ 20'\ 54''$.

| | | |
|---|---|---|
| $54^\circ\ 20'$ | tang. | .14406 |
| $54''$ | cor. | + 24 |
| $54^\circ\ 20'\ 54''$ | = tang. | .14430 |

5. **Example:** **Find the logarithm tangent for 35° 50′ 38″.**

| | | | |
|---|---|---|---|
| 35° 50′ | tang. | | 9.85860 |
| 38″ | cor. | + | 17 |
| 35° 50′ 38″ | = tang. | | 9.85877 |

6. Example: Find the logarithm cosine for 54° 27′ 40″.

| | | | |
|---|---|---|---|
| 54° 27′ | cos. | | 9.76448 |
| 40″ | cor. | — | 12 |
| 54° 27′ 40″ | = cos. | | 9.76436 |

7. Example: Find the logarithm cosine 35° 10′ 46″.

| | | | |
|---|---|---|---|
| 35° 10′ | cos. | | 9.91248 |
| 46″ | cor. | — | 7 |
| 35° 10′ 46″ | = cos. | | 9.91241 |

8. Example: Find the logarithm cosine for 86° 28′ 42″.

| | | | |
|---|---|---|---|
| 86° 28′ | cos. 8.78979 | | Dif. 1′ 204 |
| cor. for 42″ = 204 × .7 | = | — 143 | 42″ = × .7 |
| 86° 28′ 42″ | = cos. 8.78836 | | 143 = 142.8 |

$$\text{or the cor. } 142.8 = \frac{204}{60} \times 42''$$

## DEFINITIONS

Compass course is that course steered by the ship's compass. It includes variation and deviation, heeling error, current and leeway, if any.

Magnetic course is the course steered by the ship's compass when free from deviation and other influences.

True course is the course obtained by applying the variation, deviation and leeway, if any.

Leeway is the angle between the ship's keel and the direction being made through the water.

Variation is the quantity the north point of the compass is east or west of the true north. It is the earth's effect on the compass and is not the same in all localities. It is always increasing or decreasing.

Deviation is the quantity the north point of the compass is east or west of the magnetic north. It is the result of the ship's effect on the compass. It is different for every point of the compass and, therefore, changes every time the course is altered.

Compass error is the quantity the north point of the compass is east or west of the true north. If the compass is free of deviation, it will be the same as the variation.

Distance is the number of miles the ship makes on any one course or the number of miles between any two points on the earth's surface.

Distance made good is the number of miles a ship is from the point she started regardless of the distance she has sailed.

Departure course is the bearing reversed of the fixed object on shore from which a ship takes her departure upon leaving port. The distance is also noted.

Wind is air in motion and its direction is named after the point from which it blows.

Current is water having progressive motion. Its set is named after the point from which it flows and its drift is expressed in miles either hourly or daily.

Difference of latitude is the quantity taken for each corrected course and distance from the latitude column in Tables 1 or 2, taking care to use the top or bottom according to the course. They are entered in the traverse table in the north column for north courses and in the south column for south courses. It is also the north or south distance between any two points on the earth's surface.

Departure is the quantity taken for each corrected course and distance from Tables 1 or 2 and entered in the traverse table in the east column for east courses and in the west column for west courses. It is also the east or west distance between any two points on the earth's surface expressed in true or latitude miles.

Latitude is the distance any point on the earth's surface is north or south of the equator, and is expressed in degrees, minutes and seconds.

Parallel of latitude is a circle parallel to the equator and equidistant from the north or south poles.

The equator is a great circle around the globe equidistant from the poles. From it the degrees of latitude are counted north or south toward the poles.

Longitude is the distance any point on the earth's surface is east or west of the meridian of Greenwich measured on the equator and is expressed in degrees, minutes and seconds in this work, but for other purposes in hours, minutes and seconds.

A meridian is the arc of a great circle 180° extending from pole to pole, its plane cutting that of the equator at right angles.

Meridian of Greenwich is the prime meridian from which longitude is counted east or west.

Middle latitude is half the sum of the two latitudes between which a course and distance may be wanted. It is used for converting difference of longitude into departure or departure into difference of longitude, using Table 2.

Meridional parts is the distance any point on the earth's surface is north or south of the equator measured on a Mercator chart with a degree of longitude at the equator and is expressed in miles and tenths. Meridional parts are found in Table 3 for any degree or mile of latitude to latitude 79° 59′.

Meridional difference is the difference of the meridional parts for the latitudes of any two points on the earth's surface.

# TABLE OF DEVIATIONS

| Ship's Head | Dev. | Ship's Head | Dev. | Ship's Head | Dev. | Ship's Head | Dev. |
|---|---|---|---|---|---|---|---|
| N. | 7° W. | E. | 21½° W. | S. | 3° E. | W. | 20° E. |
| N. by E. | 7½ W. | E. by S. | 23 W. | S. by W. | 12 E. | W. by N. | 17 E. |
| N. N. E. | 9 W. | E. S. E. | 24 W. | S. S. W. | 18 E. | W. N. W. | 14 E. |
| N. E. by N. | 10 W. | S. E. by E. | 24 W. | S. W. by S. | 23½ E. | N. W. by W. | 9 E. |
| N. E. | 12 W. | S. E. | 23½ W. | S. W. | 26 E. | N. W. | 6 E. |
| N. E. by E. | 14½ W. | S. E. by S. | 20 W. | S. W. by W. | 27 E. | N. W. by N. | 3 E. |
| E. N. E. | 17 W. | S. S. E. | 14 W. | W. S. W. | 25 E. | N. N. W. | 0 |
| E. by N. | 19 W. | S. by E. | 6 W. | W. by S. | 22 E. | N. by W. | 3 W. |
| E. | 21½ W. | S. | 3 E. | W. | 20 E. | N. | 7 W. |

## HOW TO USE A DEVIATION TABLE

Never take deviation from the table for a bearing; but when a bearing is taken, carefully note the point the ship was heading at the time the bearing was observed. No matter what the bearing may be, take the deviation for the ship's head.

Example: Compass course W. by S.
Compass course W. by S. *Ans.*, dev. 22° 00′ E.

Example: Compass course S.
Compass course S. *Ans.*, dev. 3° 00′ E.

Example: Compass course S. ½ W.

At examinations it is usual to give the tables for whole points. When the deviation is wanted for a half point, the mean of the nearest point on each side will be the deviation for the half point.

To find the deviation for S. ½ W., take deviations from the table for S. and S. by W. and half their sum, both being east, will be the deviation for S. ½ W. Both of which being east, it takes the same name.

| | | | | |
|---|---|---|---|---|
| S. | Dev. | 3° | 00′ | E. |
| S. by W. | " + | 12 | 00 | E. |
| | 2) | 15 | 00 | |
| Dev. for S. ½ W. | Ans. = | 7 | 30 | E. |

Example: Compass course S. ½ E.

In this case the deviations for S. and S. by E. are of different name. To find the deviation for S. ½ E., take the deviations from the table for S. and S. by E. and half their difference named after the greater will be the deviation for S. ½ E.

| | | | | |
|---|---|---|---|---|
| S. | Dev.— | 3° | 00′ | E. |
| S. by E. | " | 6 | 00 | W. |
| | 2) | 3 | 00 | |
| Dev. for S. ½ E. | *Ans.* = | 1 | 30 | W. |

Correct the following courses which were steered by compass. Deviations as per table.

## PART OF A TRAVERSE TABLE

| No. | Compass Course | Wind | Leeway | Var. | Dev. | *Ans.* True Course |
|---|---|---|---|---|---|---|
| 1 | S. E. by E. | S. by W. | 1½ pt. | 15° 30′ E. | 24° 00′ W. | S. 81° 37′ E. |
| 2 | S. W. by W. | S. by E. | ½ pt. | 9 00 W. | 27° 00′ E. | S. 79 52 W. |
| 3 | N. N. W. ½ W. | N. E. | ¾ pt. | 6 00 E. | 1 30 E. | N. 29 04 W. |
| 4 | W. ½ N. | N. by W. | 1¼ pt. | 11 30 E. | 18 30 E. | N. 65 38 E. |
| 5 | E. by N. | N. N. E. | 1 pt. | 19 00 E. | 19 00 W. | East |
| 6 | N. ½ W. | W. N. W. | ½ pt. | 7 00 E. | 5 00 W. | N. 2° 00′ E. |
| 7 | S. ½ E. | E. S. E. | ½ pt. | 3 00 E. | 3 00 W. | South |
| 8 | E. ¼ S. | N. N. E. | ¼ pt. | 26 30 W. | 21 30 W. | N. 47° 38′ E. |
| 9 | N. E. ½ E. | N. N. W. | 1 pt. | 26 00 E. | 13 15 W. | N. 74 37′ E. |

### COURSE NUMBER 1

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. S. E. by E. | = S. | 5 | | pts. | E. |
| Leeway (wind S. by W.) | + | 1 | ½ | " | |
| Com. Co. cor. for leeway | S. | 6 | ½ | " | E. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S. 6½ pts. E. = in degs. | S. | 73° | 07′ | E. | Var. | — | 15° | 30′ | E. |
| Com. err. | + | 8 | 30 | W. | Dev. | | 24 | 00 | W. |
| True Co. | S. | 81 | 37 | E. | Com. err. | | 8 | 30 | W. |

### COURSE NUMBER 2

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. S. W. by W. | = S. | 5 | | pts. | W. |
| Leeway (wind S. by E.) | + | | ½ | " | |
| Com. Co. cor. for leeway | S. | 5 | ½ | " | W. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S. 5½ pts. W. = in degs. | S. | 61° | 52′ | W. | Var. | — | 9° | 00′ | W. |
| Com. err. | + | 18 | 00 | E. | Dev. | | 27 | | E. |
| True Co. | S. | 79 | 52 | W. | Com. err. | | 18 | 00 | E. |

### COURSE NUMBER 3

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. N. N. W. ½ W. | = N. | 2 | ½ | pts. | W. |
| Leeway (wind N. E.) | + | | ¾ | " | |
| Com. Co. cor. for leeway | N. | 3 | ¼ | " | W. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N. 3¼ pts. W. = in degs. | N. | 36° | 34′ | W. | Var. | | 6° | 00′ | E. |
| Com. err. | — | 7 | 30 | E. | Dev. | + | 1 | 30 | E. |
| True Co. | N. | 29 | 04 | W. | Com. err. | | 7 | 30 | E. |

### COURSE NUMBER 4

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. W. ½ N. | = N. | 7 | ½ | pts. | W. |
| Leeway (wind N. by W.) | + | 1 | | " | |
| | — N. | 8 | ½ | " | W. |
| | | 16 | | " | |
| Com. Co. cor. for leeway | S. | 7 | ½ | " | W. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S. 7½ pts. W. = in degs. | S. | 84° | 22′ | W. | Var. | 11° | 30′ | E. |
| Com. err. | + | 30 | 00 | E. | Dev. | + 18 | 30 | E. |
| | — S. | 114 | 22 | W. | Com. err. | 30 | 00 | E. |
| | | 180 | 00 | | | | | |
| True Co. | N. | 65 | 38 | W. | | | | |

### COURSE NUMBER 5

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. E. by N. | = | N. | 7 | pts. | E. |
| Leeway (wind N. N. E.) | + | | 1 | " | |
| Com. Co. cor. for leeway | | N. | 8 | " | E. |

| | | | | | | |
|---|---|---|---|---|---|---|
| N. 8 pts. E. = in degs. | N. 90° E. = East | | Var. | 19° | 00′ | E. |
| Com. err. | 0 | | Dev. | — 19 | 00 | W. |
| True Co. | East | | Com. err. | 0 | 00 | |

### COURSE NUMBER 6

| | | | | | | |
|---|---|---|---|---|---|---|
| Com. Co. N. ½ W. | = | N. | 0 | ½ | pt. | W. |
| Leeway (wind W. N. W.) | — | | | ½ | " | |
| Com. Co. cor. for leeway | | N. | 0 | 0 | " | W. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| N. 0 0 pt. = in degs. | N. | 0° | 00′ | | Var. | 7° | 00′ | E. |
| Com. err. | | 2 | | E. | Dev. | — 5 | 00 | W. |
| True Co. | N. | 2 | 00 | E. | Com. err. | 2 | 00 | E. |

### COURSE NUMBER 7

| | | | | | | |
|---|---|---|---|---|---|---|
| Com. Co. S. ½ E. | = | S. | 0 | ½ | pt. | E. |
| Leeway (wind E. S. E.) | — | | | ½ | " | |
| Com. Co. cor. for leeway | | S. | 0 | 0 | " | E. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| S. 0 0 pt. = in degs. | S. | 0° | 00′ | Var. | 3° | 00′ | E. |
| Com. err. | | 0 | | Dev. | — 3 | 00 | W. |
| True Co. | S. | 0 | 00 | Com. err. | 0 | 00 | |

### COURSE NUMBER 8

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. E. ¼ S. | = S. | 7 | ¾ | pts. | E. |
| Leeway (wind N. N. E.) | — | | ¼ | " | |
| Com. Co. cor. for leeway | S. | 7 | ½ | " | E. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S. 7½ pts. E. = in degs. | S. | 84° | 22′ | E. | Var. | | 26° | 30′ | W. |
| Com. err. | + | 48 | 00 | W. | Dev. | + | 21 | 30 | W. |
| | S. | 132 | 22 | E. | Com. err. | | 48 | 00 | W. |
| | | 180 | | | | | | | |
| True Co. | = N. | 47 | 38 | E. | | | | | |

### COURSE NUMBER 9

| | | | | | |
|---|---|---|---|---|---|
| Com. Co. N. E. ½ E. | = N. | 4 | ½ | pts. | E. |
| Leeway (wind N. N. W.) | + | 1 | | " | |
| Com. Co. cor. for leeway | N. | 5 | ½ | " | E. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N. 5½ pts. E. = in degs. | N. | 61° | 52′ | E. | Var. | | 26° | 00′ | E. |
| Com. err. | + | 12 | 45 | E. | Dev. | — | 13 | 15 | W. |
| True Co. | N. | 74 | 37 | E. | Com. err. | | 12 | 45 | E. |

## HOW TO USE TABLE 2

After the courses have been corrected, the differences of latitude and departures are taken from Table 2 for each course and distance and entered in the proper columns of a traverse table.

In Table 2 the courses are from 1 degree to 45 degrees at the top of the page and from 45 degrees to 89 degrees at the bottom of the page. Each degree is a separate table, the distances being from 1 mile to 600 miles, each column limited to 60 miles. If the corrected course is 44 degrees or less, the top of the table must be used and the columns will be in the order, "Dist. Lat. Dep." If the corrected course is 46 degrees or more, the bottom of the table must be used and the columns will be in the order, "Dist. Dep. Lat." If the corrected course is 45 degrees, either top or bottom may be used, as the differences of latitude and departures are the same. That is, if a ship sails 100 miles on the course N. E. she will make 70.7 miles north and 70.7 miles east.

Suppose the difference of latitude and departure for a course N. 31° E. and distance 47 miles is wanted.

Turn to 31° and run down the first (dist.) column to 47'. In the second (lat.) column will stand 40'.3, which should be placed in the N. column of the traverse table. In the third (dep.) column 24'.2 will be found and should be placed in the E. column of the traverse table.

If the corrected course N. 59° E. is taken with the distance 47', it will be found at the bottom and 47' will be found in the first (dist.) column. In the second (dep.) column 40'.3 will be found and should be placed in the E. column of the traverse table. In the third (dep.) column will stand 24'.2, which should be placed in the N. column of the traverse table.

Suppose the difference of latitude and departure is wanted for the corrected course N. 31° E. and distance 47.7 miles. In the third distance column on the second page 477 will be found and from the next (lat.) column 408′.9 and in the next (dep.) column 245′.7 are taken. These numbers are for 477 miles and as the distance is 47′.7 the decimal point must be moved one place to the left, so they will read 40.89 and 24.57. In this work it is not customary and seldom necessary to have these numbers to more than one decimal. For that reason they would read 40.9 and 24.6, the last figures being more than 5 are taken in.

Suppose the difference of latitude and departure is wanted for the corrected course N. 30° 30′ E. and distance 47.7 miles.

To interpolate for the half degree, the differences of latitudes and departures are taken for 30° and 31° and half their sum will be the result wanted.

Enter Table 2 as before:

| | | | | |
|---|---|---|---|---|
| Course 30°, dist. 47′.7 | Dif. lat. | 413′.1 | Dep. | 238′.5 |
| " 31, " 47.7 | " " | +408.9 | " | +245.7 |
| | | 2)822.0 | | 2)484.2 |
| | " " 41′.1 | =411.0 | " 24′.2 = | 242.1 |

Course 30° 30′, Dif. lat. 41′.1 and dep. 24′.2.

To interpolate for the half degree when the distance exceeds 600 miles, enter Table 2 with half of it, or if that is too large, use a third or a quarter; but in any case the largest that falls within the limits of the table is to be used. The mean found must be multiplied by the same number which was used to divide the distance, except when 2 is used as a divisor. Then the sum of the quantities taken for the whole degree on each side of the course will be the result wanted, which is at once entered in the traverse table.

Interpolate for 30′ when the minutes of the course falls between 15′ and 45′.

Take from Table 2 the differences of latitudes and departures for the following courses and distances;

## PART OF A TRAVERSE TABLE

| No. | Courses | Distance | Diff. Lat. | | Dep. | |
|---|---|---|---|---|---|---|
| | | | N. | S. | E. | W. |
| 1 | S. 81° 15′ E. | 8′.0 | | 1′.3 | 7′.9 | |
| 2 | S. 6 45 W. | 22.0 | | 21.8 | | 2′.7 |
| 3 | N. 48 20 W. | 41.2 | 27.3 | | | 30.9 |
| 4 | S. 62 50 W. | 36.4 | | 16.5 | | 32.4 |
| 5 | S. 18 40 W. | 53.8 | | 51.0 | | 17.1 |
| 6 | S. 16 52 E. | 19.0 | | 18.2 | 5.6 | |
| 7 | N. 42 30 E. | 63.6 | 46.9 | | 43.0 | |
| 8 | N. 88 30 E. | 64.4 | 1.7 | | 64.4 | |
| 9 | S. 56 22. W. | 61.4 | | 33.9 | | 51 2 |
| 10 | N. 34 46 W. | 3.2 | 2.6 | | | 1.8 |
| 11 | N. 3 30 W. | 137.4 | 137.1 | | | 8.4 |

### COURSE NUMBER 1

Enter Table 2 with the course 81°, which is found at the bottom of the page. With 8 miles in the distance column and reading from the bottom of the page, take out the difference of latitude, 1′.3, and place it in the south column, because the course is south. Also take the departure and place it in the east column, because the course is east.

### COURSE NUMBER 2

As this course is 6° 45′, 7° is used to enter Table 2 and is found at the top of the page. With 22 miles in the distance column, the difference of latitude, 21′.8 for the south column and 2′.7 for the west column, are found.

### COURSE NUMBER 3

This course is 48° 20′ and is interpolated for by taking out difference of latitude and departure for 48° and 49°, using the bottom of the page. The distance being 41.2 miles, 412 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left.

| | | | |
|---|---|---|---|
| Course 48° dist. 412′ dif. lat. | 30′.62 | Dep. | 27.57 |
| “ 49 “ 412 “ “ | +31.09 | “ | +27.03 |
| | 2)61.71 | | 2)54.60 |
| “ “ 30′.9 | =30.85 | “ 27′.3 | =27.30 |

As the course lies between south and west, the difference of latitude and departure are placed in those columns.

### COURSE NUMBER 4

As this course is 62° 50′, 63″ is used to enter Table 2 and is found at the bottom of the page. The distance being 36.4 miles, 364 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left, giving the difference of latitude 16′.5 and departure 32′.4, which are placed in the south and west columns.

### COURSE NUMBER 2

As this course is 18° 40′, it is interpolated for by taking out the differences of latitude and departure for 18° and 19°, which are found at the top of the page. The distance being 53.8 miles, 538 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left.

| | | | |
|---|---|---|---|
| Course 18° dist. 538′ Dif. lat. | 51.17 | Dep. | 16.62 |
| “ 19 “ 538 “ “ | +50.87 | “ | +17.51 |
| | 2)102.04 | “ | 2)34.13 |
| “ “ 51′.0 | =51.02 | “ 17′.1 | =17.06 |

As the course lies between south and west, the difference of latitude and departure are placed in those columns.

### COURSE NUMBER 6

As this course is 16° 52′, the difference of latitude and departure are taken from Table 2 for 17°, which is found at the top of the page. There being no decimals in the distance, which is 19 miles, the difference of latitude, 18′.2, and departure, 5′.6, are at once entered in the traverse table.

### COURSE NUMBER 7

This course is 42° 30′ and is interpolated for by taking out the difference of latitude and departure for 42° and 43°, which are found at the top of the page. The distance being 63.6 miles, 636 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left. But 636 miles is beyond the limits of Table 2, and for that reason half of it, 318 miles, is used.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course | 42° | dist. | 318′ | Dif. lat. | | 23′.63 | Dep. | | 21.28 |
| “ | 43 | “ | 318 | “ “ | | +23.26 | “ | | +21.69 |
| | | | | “ “ | 46′.9 | =46.89 | “ | 43′.0 | =42.97 |

The sum of the numbers take from Table 2 are not divided by 2 because half the distance was used, and the sums are placed in the proper columns of the traverse table as they are.

### COURSE NUMBER 8

This course is 88° 30′ and is interpolated for by taking the difference of latitude and departure for 88° and 89°, which are found at the bottom of the page. The distance being 64.4 miles, 644 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left. As 644 miles is beyond the limits of the table, half of it, 322 miles, is used.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course | 88° | dist. | 322′ | def. lat. | | 1.12 | Dep. | | 32′.18 |
| “ | 89 | “ | 322 | “ “ | | + .56 | “ | | + 32.20 |
| | | | | “ “ | 1′.7 | =1.68 | “ | 64′.4 | =64.38 |

The sum of the numbers taken from Table 2 are not divided by 2, because half the distance was used, and the sums are placed in the proper columns of the traverse table as they are.

### COURSE NUMBER 9

This course is 56° 22′ and is interpolated for by taking the differences of latitude and departure for 56° and 57°, which are found at the bottom of the page. The distance being 61.4 miles, 614 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left. As 614 miles is beyond the limits of the table, half of it, 307 miles, is used.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course | 56° | dist. | 307 | Dif. lat. | | 17.17 | Dep. | | 25.45 |
| " | 57 | " | 307 | " " | | + 16.72 | " | | + 25.75 |
| | | | | " " | 33′.9 | = 33.89 | " | 51′.2 | = 51.20 |

The sum of the numbers taken from Table 2 are not divided by 2 because half the distance was used, and the sums are placed in the proper columns of the traverse table as they are.

### COURSE NUMBER 10

As this course is 34° 46′, the differences of latitude and departure are taken for 35°, which is found at the top of the page. The distance being 3.2 miles, 32 miles is used, which necessitates moving the decimal points in the numbers from Table 2 one place to the left, the result being difference of latitude 2.65, reduced to one decimal place is 2′.7. The departure, 1.79, also reduced to one decimal place, is 1′.8, which are placed in the proper columns of the traverse table.

### COURSE NUMBER 11

This course is 3° 30′ and is interpolated for by taking the difference of latitude and departure for 3° and 4°, which are found at the top of the page. The distance being 137.4 miles, 1374 miles is used; but it is beyond the limits of the table. As half of it, 687 miles, is also too large, a third, 458 miles, is used.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course | 3° 00′ | dist. | 458′ | Dif. lat. | | 45′.73 | Dep. | | 2′.40 |
| “ | 4 00′ | “ | 458 | “ “ | | 45.69 | “ | | 3.19 |
| | | | | | | 2)91.42 | | | 2)5.59 |
| “ | 3 30′ | “ | 45.8 | “ “ | | 45.71 | “ | | 2.79 |
| | | | | | | ×3 | | | ×3 |
| “ | 3 30 | “ | 137.4 | “ “ | 137′.1 = | 137.13 | “ | 8′.4 = | 8.37 |

By this operation the mean of the numbers from Table 2 are for one-third of the distance, which is 45.8 miles, which are multiplied by 3 to obtain the difference of latitude, 137′.1, and departure, 8′.4, for the whole distance, 137′.4.

## TO FIND COURSES AND DISTANCES FROM TABLE 2

When all the differences of latitude and departures have been entered in the traverse table, each column is added separately. The difference is then found between the sums of the north and south columns and is given the name of the greater. The difference is also found between the sums of the east and west columns, which takes the name of the greater. With the difference of latitude and departure thus found, enter Table 2. If the difference of the latitude is greater than the departure, it shows that the course made or wanted is nearer to north or south than to east or west and the course is less than 45°, which must be found at the top of the page. On the other hand, if the departure is greater than the difference of latitude, the course must lie nearer to east or west than to north or south and then the course must be more than 45° and is found at the bottom of the page. Where the difference of latitude and departure are found to agree nearest in Table 2, the course and distance are taken.

To find the numbers in Table 2 which nearly agree with the difference of latitude and departure found by the traverse table, open Table 2 at any degree and find either the difference of latitude or departure in the proper column, turn over one page, and if the two more nearly agree, continue that way until they do agree as near as possible. Otherwise go the other way until they agree as near as possible.

1. Example: With difference of latitude 107′.2 S. and departure 64′.3 E., find the course and distance.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 107'.2\text{ S.}\\ \text{Dep.} & 64.3\text{ E.}\end{array}\right\} = \text{Course S. } 31^\circ\text{ E. distance } 125'.$$

2. Example: With difference of latitude 297′.6 N., departure 193′.4 E., find the course and distance.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 297'.6\text{ N.}\\ \text{Dep.} & 193.4\text{ E.}\end{array}\right\} = \text{Course N. } 33^\circ\text{ E., distance } 355'.$$

3. Example: With difference of latitude 542′.2 S. and departure 28′.7 W., find the course and distance.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 542'.2\text{ S.}\\ \text{Dep.} & 28.7\text{ W.}\end{array}\right\} = \text{Course S. } 3^\circ\text{ W., distance } 543'.$$

4. Example: With difference of latitude 322′.8 N. and departure 74′.8 W., find the course and distance.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 322'.8\text{ N.}\\ \text{Dep.} & 74.8\text{ W.}\end{array}\right\} = \text{Course N. } 77^\circ\text{ W., distance } 331'.$$

5. Example: With difference of latitude 48′.9 S. and departure 930′.4 E., find the course and distance.

In this case the departure, 930′.4, is beyond the limits of the table, which require that half of it, 465′.2, be used with half the difference of latitude, 24′.4, which will give the course and half the distance.

$$\left.\begin{array}{l}\tfrac{1}{2}\text{ dif. lat. } 48'.9\text{ S.} = 24'.4 \\ \tfrac{1}{2}\text{ dep. } \quad 930.4\text{ E.} = 465.2\end{array}\right\} = \text{Course S. } 87^\circ\text{ E. and half the}$$

distance, 466' × 2 = distance 932'.

6. Example: With difference of latitude 347'.1 N. and departure 347'.2 E., find the course and distance.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 347'.1\text{ N.} \\ \text{Dep.} & 347.2\text{ E.}\end{array}\right\} = \text{Co. N. } 45^\circ\text{ E., distance } 491'.$$

When the difference of latitude and departure are the same, the course is 45°.

7. Example: With difference of latitude 2'.4 S. and departure 3'.7 E., find the course and distance.

When these quantities are so small, the correct result cannot be taken from the table unless the decimal is moved one place to the right and then the course and distance can be found; but when the distance is taken out, the decimal point must be moved one place to the left.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 2'.4\text{ S.} \\ \text{Dep.} & 3.7\text{ E.}\end{array}\right\} = \text{Course S. } 57^\circ\text{ E., distance } 4'.4.$$

## MIDDLE LATITUDE SAILING BY INSPECTION

Having the latitudes and longitudes of the two points between which the course and distance is wanted, find their differences and name them after the direction the point lies to which the course is to be found. As the miles of longitude are not the same as those of latitude, the middle latitude is found by adding together the two latitudes under consideration and dividing their sum by 2, which will be the middle latitude, the nearest degree of which is used for converting the difference of longitude into departure by entering Table 2 with it as if a course and finding the difference of longitude in the distance column and the corresponding number in the latitude column will be the departure. The departure may be used in a similar manner for converting departure into difference of longitude.

Enter Table 2 with the difference of latitude and departure, and where they agree, or nearly so, the course and distance will be found.

### EXAMPLE NUMBER I

Both latitudes and longitudes to find the course and distance: A ship is in latitude 36° 51′ 00″ N. and longitude 70° 55′ 45° W. Find the course and distance to Barnegat light in latitude 39° 45′ 52″ N. and longitude 74° 06′ 24″ W.

| | | | | | |
|---|---|---|---|---|---|
| Lat. ship | —36° 51′ 00″ | N. | Long. ship. | —70° 55′ 45″ | W. |
| Lat. Barnegat | 39 45 52 | N. | Long. Barnegat | 74 06 24 | W. |
| Dif. 174′.9 = | 2 54 52 | N. | Dif. 190′.65 = | 3 10 39 | W. |

Lat. ship 36° 51′ 00″ N.
Lat. B. + 39 45 52 N.
2)76 36 52
Mid. lat. = 38 18 26 = 18°, dif. long. 190′.65 = dep. 150′.5 W.

Dif. lat. 174′.9 N.
Dep. 150.5 W. } = Course N. 41° W., distance 230′.0.

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of Barnegat light, convert it into miles and name it north because Barnegat light is north of the latitude of the ship.

Find the difference of longitude by subtracting the longitude of the ship from that of Barnegat light, convert it into miles and name it west, because Barnegat light is west of the longitude of the ship.

Add together the latitude of the ship and that of Barnegat light. Then divide by 2, which will give the middle latitude, the nearest degree of which is 38°.

With 38° enter Table 2 and find the difference of longitude, which to the nearest mile is 191′.0, which is found in the distance column, and the corresponding number in the latitude column will be the departure, 150′.5 W.

Enter Table 2 with the difference of latitude 174′.9 N. and departure 150′.5 W. and they will be found to agree nearly, giving the course N. 41° W. and the distance 230′.0.

### EXAMPLE NUMBER 2

Both latitudes, one longitude and departure to find the course and distance, and longitude in: A ship left a point in latitude 37° 55′ 25″ N. and longitude 74° 56′ 22″ W. and arrived in latitude 35° 57′ 25″ N., the departure being 216′.5 E. Find the course and distance and longitude of the ship.

| | | | |
|---|---|---|---|
| Lat. point | 37° 55′ 25″ N. | Long. point | 74° 56′ 22″ W. |
| Lat. ship | — 35 57 25 N. | Dif. 271′.0 = | — 4 31 00 E. |
| Dif. 118′.0 = | 1 58 00 S. | Long. ship. | 70 25 22 W. |

Lat. point 37° 55′ 25″ N.
Lat. ship + 35 57 25 N.
2) 73 52 50
Middle lat. = 36 56 25 = 37° dep., 216′.5 = dif. long. 271′.0 E.

Dif. lat. 118′.0 S.
Dep. 216 .5 E. } = Course S. 61° E., distance 247′.0.

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of the point left, convert it into miles and name it south, because the ship has sailed south.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude, the nearest degree of which is 37°.

With 37° enter Table 2 and find the departure 216′.5 E. in the latitude column, and the corresponding number in the distance column will be the difference of longitude, 271′.0 E., which is subtracted from the longitude of the point left, because the ship has sailed east and in doing so has decreased the longitude.

Enter Table 2 with the difference of latitude 118′.0 S. and departure 216′.5 E. and they will be found to agree nearly, giving the course S. 61° E. and distance 247′.

### EXAMPLE NUMBER 3

One latitude, one longitude, course and distance to find the latitude and longitude of the ship: A ship sailed S. 65° E. for 362′.0 from a point in latitude 35° 15′ 17″ N. and longitude 75° 31′ 16″ W. Find the latitude and longitude in.

$$\left.\begin{array}{l}\text{Co. S. } 65^\circ \text{ E.}\\ \text{Dist. } 362'.0\end{array}\right\} = \left\{\begin{array}{ll}\text{Dif. lat.} & 153.0\text{ S.}\\ \text{Dep.} & 328.0\text{ E.}\end{array}\right.$$

| | | | |
|---|---|---|---|
| Lat. left | 35° 15′ 17″ N. | Long. left | 75° 31′ 16″ W. |
| Dif. 153′.0 = | — 2 33 00 S. | Dif. 396′.0 = | — 6 36 00 E. |
| Lat. ship. | 32 42 17 N. | Long. ship. | 68 55 16 W. |

Lat. left 35° 15′ 17″ N.
Lat. ship + 32 42 17 N.
2)67 57 34
Middle lat. = 33 58 47 = 34° dep. 328′.0 dif. long. 396′.0 E.

## EXPLANATION

Enter Table 2 with the course S. 65° E. and distance 362′.0 and take out the difference of latitude 153′.0 S. and departure 328′.0 E.

Subtract the difference of latitude from the latitude left and the result will be the latitude of the ship.

Add together the latitude of the point left and the latitude of the ship. Then divide by 2, which will give the middle latitude, the nearest degree of which is 34°.

With 34° enter Table 2 and find the departure 328′.0 in the latitude column, and the corresponding number in the distance column will be the difference of longitude 396′.0 E.

Subtract the difference of longitude from the longitude left and the result will be the longitude of the ship.

### EXAMPLE NUMBER 4

Both latitudes, one longitude and course to find the distance and longitude in: A ship was sailed S. 56° W. from a point in latitude 34° 21′ 12″ S. and longitude 18° 29′ 26″ E. to latitude 37° 10′ 15″ S. Find the distance and longitude of the ship.

| | | | |
|---|---|---|---|
| Lat. left | —34° 21′ 12″ S. | Long. left | 18° 29′ 26″ E. |
| Lat. ship | 37 10 25 S. | Dif. 310′.5 W. = | —5 10 30 W. |
| Dif. 169′.2 = | 2 49 13 S. | Long. ship | 13 18 56 E. |

Co. S. 56° W. } = { Dep. 251′.2 W.
Dif. lat. 169′.2 } = { Dist. 303.0

Lat. left 34° 21′ 12″ S.
Lat. ship + 37 10 25 S.
2)71 31 37
Middle lat. = 35 45 48 = 36° dep. 251′.2 = dif. long. 310′.5 W.

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the point left from that of the ship, convert it into miles and name if south because the ship has sailed south.

Enter Table 2 with the course S. 56° W. and the difference of latitude 169′.2 in the latitude column, and find the departure 251′.2 in the departure column and the distance 303′.0 in the distance column.

Add together the latitude of the point left and the latitude of the ship. Then divide by 2, which will give the middle latitude, the nearest degree of which is 36°.

With 36° enter Table 2 and find the departure 251′.2 in the latitude column, and the corresponding number in the distance column will be the difference of longitude 310′.5 W., which is subtracted from the longitude of the point left because the ship has sailed west and in doing so it has decreased the longitude.

### EXAMPLE NUMBER 5

Both latitudes, one longitude and distance to find the course and longitude in: A ship was sailed 392′.0 easterly from a point in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to latitude 57° 05′ 30″ S. Find the course, latitude and longitude of the ship.

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | | — 55° 58′ 41″ S. | Long. left | | 67° 16′ 15″ W. |
| Lat. ship | | 57 05 30 S. | Dif. | 699′ = | — 11 39 00 E. |
| Dif. | 66′.8 = | 1 06 49 S. | Long. ship | | 55 37 15 W. |

$$\left.\begin{array}{ll}\text{Dist.} & 392'.0\\ \text{Dif. lat.} & 66.8\text{ S.}\end{array}\right\} = \left\{\begin{array}{l}\text{Co. S. } 80^\circ\text{ E.}\\ \text{Dep. } 386'.0\text{ E.}\end{array}\right.$$

Lat. left 55° 58′ 41″ S.
Lat. ship + 57 05 30 S.
2) 113 04 11
Middle lat. = 56 32 05 = 56° ½ dep. 386′.0 = dif. long. 699′.0 E.

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the point left from that of the ship, convert it into miles and name it south, because the ship has sailed south.

Enter Table 2 with the distance 392′.0 and the difference of latitude 66′.8 S. and find them to agree in their respective columns, and the departure 386′.0 E. will be found in the departure column and the course S. 80° E. at the bottom of the page.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude, the nearest degree of which is 56½°.

With the middle latitudes 56° and 57° enter Table 2 and find half of the departure 193′.0 E. in the latitude columns and the corresponding numbers in the distance columns added together will be the difference of longitude 699′.0 E., which is subtracted from the longitude of the point left because the ship has sailed east and in doing so has decreased the longitude.

### EXAMPLE NUMBER 6

One latitude, one longitude, course and departure to find the distance, latitude and longitude in: A ship was sailed S. 67° 30′ W. from a point in latitude 40° 37′ 02″ N. and longitude 69° 37′ 05° W., making 342′.0 departure. Find the distance, latitude and longitude of the ship.

$$\left.\begin{array}{ll}\text{Co. S. } 67^\circ\, 30' \text{ W.} \\ \text{Dep.} & 342'.0 \text{ W.}\end{array}\right\} = \left\{\begin{array}{ll}\text{Dif. lat.} & 141'.6 \text{ S.} \\ \text{Dist.} & 370.0\end{array}\right.$$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lat. left | | 40° 37′ 02″ | N. | Long. left | | 69° 37′ 05″ | W. |
| Dif. | 141′.6 — | 2 21 36 | S. | Dif. | 443′.0 = + | 7 23 00 | W. |
| Lat. ship | | 38 15 26 | N. | Long. ship | | 77 00 05 | W. |

| | | |
|---|---|---|
| Lat. left | 40° 37′ 02″ | N. |
| Lat. ship | + 38 15 26 | N. |
| | 2)78 52 28 | |
| Middle lat. | = 39 26 14 = 39° ½ dep. 342′.0 = dif.long. 443′.0. | |

## EXPLANATION

Enter Table 2 with the course S. 67° 30′ W. and find the departure 342′.0 W. in the departure column and the difference of latitude 141′.6 S. and the distance 370′.0 will be found in their respective columns.

The difference of latitude 141′.6 S. subtracted from the latitude left will give the latitude of the ship.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude, the nearest degree of which is 39½°.

With the middle latitudes 39° and 40° enter Table 2 and find the departure 342′.0 in the latitude columns and the corresponding numbers in the distance columns added together and divided by 2 will be the difference of longitude 443′.0 W., which is added to the longitude of the point left because the ship has sailed west and in doing so has increased the longitude.

### EXAMPLE NUMBER 7

One latitude, one longitude, distance and departure to find the course, latitude and longitude in: A ship was sailed 428′.0 to the southward and made departure 214′.0 E. from a point in latitude 20° 15′ 00″ N. and longitude 74° 08′ 01″ W. Find the course, latitude and longitude of the ship.

$$\left.\begin{array}{l}\text{Dist. } 428'.0 \text{ S.}\\ \text{Dep. } 214.0 \text{ E.}\end{array}\right\} = \left\{\begin{array}{l}\text{Dif. lat. } 370'.7 \text{ S}\\ \text{Co. S. } 30^\circ \text{ E.}\end{array}\right.$$

| | | | |
|---|---|---|---|
| Lat. left. | 20° 15′ 00″ N. | Long. left | 74° 08′ 01″ W. |
| Dif. 370′.7 = — | 6 10 42 S. | Dif. 224′.0 = — | 3 44 00. E. |
| Lat. ship | 14 04 18 N. | Long. ship | 70 24 01 W. |

Lat. left. 20° 15′ 00″ N.
Lat. ship + 14 04 18 S.
2)34 19 18
Middle = 17 09 39 = 17° dep. 214′.0 E. = dif. long. 224′.0 E.

## EXPLANATION

Enter Table 2 with the distance 428′.0 S. and departure 214′.0 E. and find them to agree in their respective columns and the difference of latitude 370′.7 S will be found in the latitude column and the course S. 30° E. at the top of the page.

The difference of latitude 370′.7 S. subtracted from the latitude left will give the latitude of the ship.

Add together the latitude left and that of the ship. Then divide by 2, which will give the middle latitude, the nearest degree of which is 17°.

With the middle latitude 17° enter Table 2 and find the departure 214′.0 E. in the latitude column and the corresponding number in the distance column will be the difference of longitude 224′.0 E., which is subtracted from the point left because the ship has sailed east, and in doing so has decreased the longitude.

### EXAMPLE NUMBER 8

Both latitudes (one north and the other south) and both longitudes to find the course and distance: A ship is in latitude 4° 32′ 45″ N. and longitude 25° 35′ 45″ W. Find the course and distance to a point in latitude 1° 30′ 45″ S. and longitude 24° 05′ 15″ W.

| | | | | | |
|---|---|---|---|---|---|
| Lat. ship | 4° 32′ 45″ | N. | Long. ship. | 25° 35′ 45″ | W. |
| Lat. point | +1 30 45 | S. | Long. point | —24 05 15 | W. |
| Dif. | 363′.5 = 6 03 30 | S. | Dif. | 90′.5 = 1 30 30 | E. |

Greater lat. 2)4° 32′ 45″
Middle lat. 2 16 22 = 2° dif. long. 90′.5 = dep. 90′.4.

$$\left.\begin{array}{ll}\text{Dif. lat.} & 363'.5\\ \text{Dep.} & 90.4\end{array}\right\} = \text{Co. S. } 14^\circ \text{ E. distance } 375'.0.$$

This method will satisfy the ordinary demands of practice; but should not be used when the latitudes of the places under consideration lie on opposite sides of the equator. In such cases the course, distance, etc., should be found by Mercator sailing.

## EXPLANATION

Find the difference of latitude by adding the latitude of the point to that of the ship, convert it into miles and name it south because the point is south of the latitude of the ship.

When one latitude is north and the other south, the middle latitude can best be found by taking half the greater latitude, which has been done in this case, and gives the middle latitude to the nearest degree, which is 2°.

Find the difference of longitude by subtracting the longitude of the point from that of the ship, convert it into miles, and name it east because the longitude of the point is east of the longitude of the ship.

With 2° enter Table 2 and find the difference of longitude 90′.5 in the distance column and the corresponding number in the latitude column will be the departure 90′.4.

Enter Table 2 with the difference of latitude 363′.5 and departure 90′.4 and they will be found to agree nearly, giving the course S. 14° E. distance 375′.0.

When the places under consideration lie so near the equator, it is not necessary to use middle latitude sailing unless requested to do so at an examination, as plain sailing, in which the degrees of latitude and longitude are supposed to be equal, will give a result practically the same.

# MIDDLE LATITUDE SAILING BY LOGARITHMS

For ordinary purposes the course and distance found by inspection is quite satisfactory; but when the distance between the two points is too great or an exact result is wanted, it is necessary to use logarithms and is the method usually required at examinations.

A general description of the various operations is not given here; but in its place an individual explanation follows each example.

The following table contains the necessary rules for the solution of any problem by middle latitude sailing:

Mid. lat. = prop. dif. lat. ÷ mer. dif. lat.

| Ex. | Given. | To Find. | Methods. | |
|---|---|---|---|---|
| 1 | Both lats. and longs. | Dep.<br>Co.<br>Dist. | Dep.<br>Tang. co.<br>Tang. co.<br>Dist.<br>Dist. | = dif. long. × cos. mid. lat.<br>= dep. ÷ dif. lat.<br>= (cos. mid. lat. × dif. long.) ÷ dif. lat.<br>= sec. co. × dif. lat.<br>= dep. ÷ sin. co. |
| 2 | Both lats. and dep. | Co.<br>Dist.<br>Dif. long. | Tang. co.<br>Dist.<br>Dif. long. | = dep. ÷ dif. lat.<br>= dep. ÷ sin. co.<br>= dep. ÷ cos. mid. lat. |
| 3 | One lat. co. and dist. | Dif. lat.<br>Dep.<br>Dif. long. | Dif. lat.<br>Dep.<br>Dif. long.<br>Dif. long. | = dist. × cos. co.<br>= dist. × sin. co.<br>= dep. × sec. mid. lat.<br>= dist. × sin. co. × sec. mid. lat. |
| 4 | Both lats. and co. | Dep.<br>Dist.<br>Dif. long. | Dep.<br>Dist.<br>Dif. long.<br>Dif. long. | = dif. lat. × tang. co.<br>= dif. lat. ÷ cos. co.<br>= dep. × sec. mid. lat.<br>= dif. lat. × tang. co. × sec. mid. lat. |
| 5 | Both lats. and dist. | Co.<br>Dep.<br>Dif. long. | Cos. co.<br>Dep.<br>Dif. long. | = dif. lat. ÷ dist.<br>= dist. × sin. co.<br>= dep. × sec. mid. lat. |
| 6 | One lat. co. and dep. | Dif. lat.<br>Dist.<br>Dif. long. | Dif. lat.<br>Dist.<br>Dif. long. | = dep. ÷ tang. co.<br>= dep. ÷ sin. co.<br>= dep. × sec. mid. lat. |
| 7 | One lat. dist. and dep. | Co.<br>Dif. lat.<br>Dif. long. | Sin. co.<br>Dif. lat.<br>Dif. long. | = dep. ÷ dist.<br>= dist. × cos. co.<br>= dep. × sec. mid. lat. |

### EXAMPLE NUMBER I

Both latitudes and longitudes to find the course and distance: A ship is in latitude 36° 51′ 30″ N. and longitude 70° 55′ 45″ W. Find the course and distance to Barnegat light in latitude 39° 45′ 52″ N. and longitude 74° 06′ 24″ W.

| | | | | | |
|---|---|---|---|---|---|
| Lat. ship | —36° 51′ 00″ | N. | Long. ship | —70° 55′ 45″ | W. |
| Lat. Barnegat | 39 45 52 | N. | Long. Barnegat | 74 06 24 | W. |
| Dif. 174′.9= | 2 54 52 | N. | Dif. 190′.6 = | 3 10 39 | W. |

| | |
|---|---|
| Lat. ship | 36° 51′ 00″ |
| Lat. Barnegat | 39 45 52 |
| | 2)76 36 52 |
| Middle latitude | 38 18 26 |

| | |
|---|---|
| Dif. long. | 190′.6 2.28012 |
| Mid. lat. 38° 18′ 26″ | Cos. + 9.89471 |
| Dep. | 149.6 = 2.17483 |
| Dif. lat. | 174′.9 — 2.24279 |
| Co. N. 40° 32′ W. | = tang. 9.93204 |

| | |
|---|---|
| Co. N. 40° 32′ W. | sec. .11917 |
| Dif. lat. | 174′.9 + 2.24279 |
| Dist. | 230′.1 = 2.36196 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of Barnegat light, convert it into miles and name it north because Barnegat light is north of the latitude of the ship.

Find the difference of longitude by subtracting the longitude of the ship from that of Barnegat light, convert it into miles and name it west because Barnegat light is west of the longitude of the ship.

Add together the latitude of the ship and that of Barnegat light. Then divide by 2, which will give the middle latitude.

To the logarithm of the difference of longitude 190′.6 add the logarithm cosine of the middle latitude 38° 18′ 26″, which gives the logarithm of the departure 149′.6 and from that subtract the logarithm of the difference of latitude 174′.9 and the result will be the logarithm tangent of the course N. 40° 32′ W.

To the logarithm secant of the course N. 40° 32′ W. add the logarithm of the difference of latitude 174′.9, which gives the logarithm of the distance 230′.1.

### EXAMPLE NUMBER 2

Both latitudes, one longitude and departure to find the course and distance, and longitude in: A ship left a point in latitude 37° 55′ 25″ N. and longitude 74° 56′ 22″ W. and arrived in latitude 35° 57′ 25″ N., the departure being 216′.5 E. Find the course and distance and longitude of the ship.

| | | | |
|---|---|---|---|
| Lat. point | 37° 55′ 25″ N. | Long. point | 74° 56′ 22″ W. |
| Lat. ship | 35 57 25 N. | Dif. 270′.9 = — | 4 30 54 E. |
| Dif. 118′.0 = | 1 58 00 S. | Long. ship | 70 25 28 W. |

| | |
|---|---|
| Lat. point | 37° 55′ 25″ |
| Lat. ship | 35 57 25 |
| | 2)73 52 50 |
| Middle lat. | 36 56 25 |

| | | |
|---|---|---|
| Dep. | 216′.5 | 2.33546 |
| Mid. lat. | 36° 56′ 25″ cos. | — 9.90269 |
| Dif. long. 4° 30′ 54″ E. | = 270′.9 = | 2.43277 |

| | | |
|---|---|---|
| Dep. | 216′.5 | 2.33546 |
| Dif. lat. | 118.0 — | 2.07188 |
| Co. S. 61° 24′ E. | = tang. | 0.26358 |

| | | |
|---|---|---|
| Dep. | 216′.5 | 2.33546 |
| Co. S. 61° 24′ E. | sin. | — 9.94349 |
| Dist. | 246.6 = | 2.39197 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of the point left, convert it into miles and name it south because the ship has sailed south.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude.

From the logarithm of the departure 216′.5 subtract the logarithm cosine of the middle latitude 36° 56′ 25″, which will give the difference of longitude 270′.9, which is subtracted from the longitude of the point left because the ship has sailed east and by doing so has decreased the longitude.

From the logarithm of the departure 216′.5 subtract the logarithm of the difference of latitude 118′.0, which will give the logarithm tangent of the course S. 61° 24′ E.

From the logarithm of the departure 216′.5 subtract the logarithm sine of the course S. 61° 24′ E. and the result will be the logarithm of the distance 246′.6.

### EXAMPLE NUMBER 3

One latitude, one longitude, course and distance to find the latitude and longitude of the ship: A ship sailed S. 65° E. for 362'.0 from a point in latitude 35° 15' 17" N. and longitude 75° 31' 16" W. Find the latitude and longitude in.

| | |
|---|---|
| Dist. 362'.0 | 2.55871 |
| Co. S. 65° E. | Cos. + 9.62595 |
| Dif. lat. 2° 33' 00" S. | = 153'.0 = 2.18466 |

| | |
|---|---|
| Dist. 362'.0 | 2.55871 |
| Co. S. 65° E. | sin. + 9.95728 |
| Dep. 328'.1 | = 2.51599 |

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | | 35° 15' 17" N. | Long. left | | 75° 31' 16" W. |
| Dif. | 152'.0 = | — 2 33 00 S. | Dif. | 395'.7 = | — 6 35 42 E. |
| Lat. ship | | 32 42 17 N. | Long. ship | | 68 55 34 W. |

| | |
|---|---|
| Lat. left | 35° 15' 17" N. |
| Lat. ship | + 32 42 17 N. |
| | 2)67 57 34 |
| Middle lat. | 33 58 47 |

| | |
|---|---|
| Dep. 328'.1 | 2.51599 |
| Mid. lat. 33° 58' 47" | Sec. + .08133 |
| Dif. long. 6° 35' 42" E. | = 395'.7 = 2.59732 |

## EXPLANATION

To the logarithm of the distance 362'.0 add the logarithm cosine of the course S. 65° E., which gives the logarithm of the difference of latitude 153'.0 and is subtracted from the latitude left because the ship has sailed south.

To the logarithm of the distance 362'.0 add the logarithm sine of the course S. 65° E., which gives the logarithm of the departure 328'.1.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude.

To the logarithm of the departure 328′.1 add the secant of the middle latitude 33° 58′ 47″ and the result will be the difference of longitude 395′.7, which is subtracted from the longitude of the point left because the ship has sailed east and in doing so has decreased the longitude.

### EXAMPLE NUMBER 4

Both latitudes, one longitude and course to find the distance and longitude in: A ship was sailed S. 56° W. from a point in latitude 34° 21′ 12″ S. and longitude 18° 29′ 26″ E. to latitude 37° 10′ 25″ S. Find the distance and longitude of the ship.

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | | — 34° 21′ 12″ | S. | Long. left | 18° 29′ 26″ E. |
| Lat. ship | | 37 10 25 | S. | Dif. 309′.1 W. = — | 5 09 06 W. |
| Dif. | 169′.2 = | 2 49 13 | S. | Long. ship | 13 20 20 E. |

| | | | |
|---|---|---|---|
| Dif. lat. | 169′.2 | | 2.22840 |
| Co. S. 56° W. | tang. | + | .17101 |
| Dep. | 250′.8 | = | 2.39441 |

| | | | |
|---|---|---|---|
| Co. S. 56° W. | sec. | + | .25244 |
| Dif. lat. | 169′.2 | | 2.22840 |
| Dist. | 302′.6 | = | 2.48084 |

| | | | |
|---|---|---|---|
| Lat. left | | 34° 21′ 12″ | S. |
| Lat. ship | + | 37 10 25 | S. |
| | 2) | 71 31 37 | |
| Middle lat. | | 35 45 48 | |

| | | | |
|---|---|---|---|
| Dep. | 250′.8 | | 2.39941 |
| Mid. lat. 35° 45′ 48″ | sec. | + | .09074 |
| Dif. long. | 309′.1 | | 2.49015 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the point left from that of the ship, convert it into miles and name it south because the ship has sailed south.

To the logarithm of the difference of latitude 169′.2 add the logarithm tangent of the course S. 56° W., which gives the logarithm of the departure 250′.8.

To the logarithm of the difference of latitude 169′.2 add the logarithm secant of the course S. 56° W., which gives the logarithm of the distance 302′.6.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude.

To the logarithm of the departure 250′.8 add the logarithm of the middle latitude 35° 45′ 48″ and the result will be the logarithm of the difference of longitude 309′.1, which is subtracted from the longitude of the point left because the ship has sailed west and in doing so has decreased the longitude.

### EXAMPLE NUMBER 5

Both latitudes, one longitude and distance to find the course and longitude in: A ship was sailed 392′.0 easterly from a point in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to latitude 57° 05′ 30″ S. Find the course, latitude and longitude of the ship.

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | | — 55° 58′ 41″ S. | Long. left | | 67° 16′ 15″ W. |
| Lat. ship | | 57 05 30 S. | Dif. | 698′.9 — | 11 38 54 E. |
| Dif. | 66′.8 = | 1 06 49 S. | Long. ship | | 55 37 21 W. |

| | | |
|---|---|---|
| Dif. lat. | 66′.8 | 1.82478 |
| Dist. | 392.0 — | 2.59329 |
| Co. S. 80° 11′ E. | = cos. | 9.23149 |

| | | |
|---|---|---|
| Dist. | 392′.0 | 2.59329 |
| Co. S. 80° 11′ E. | sin. + | 9.99359 |
| Dep. | 386′.3 = | 2.58688 |

| | | |
|---|---|---|
| Lat. left | | 55° 48′ 41″ S. |
| Lat. ship | + | 57 05 30 S. |
| | 2) | 112 54 11 |
| Middle lat. | | 56 27 05 |

| | | |
|---|---|---|
| Dep. | 386′.3 | 2.58688 |
| Mid. lat. 56° 27′ 05″ | sec. + | .25756 |
| Dif. long. 11° 38′ 54″ E. | = 698′.9 = | 2.84444 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the point left from that of the ship and name it south because the ship has sailed south.

From the logarithm of the difference of latitude 66′.8 subtract the logarithm of the distance 392′.0, which gives the cosine of the course S. 80° 11′ E.

To the logarithm of the distance 392′.0 add the logarithm sine of the course S. 80° 11′ E., which gives the logarithm of the departure 386′.3.

Add together the latitude left and that of the ship. Then divide by 2, which will give the middle latitude.

To the logarithm of the departure 386′.3 add the logarithm secant of the middle latitude 56° 27′ 05″ and the result will be the difference of longitude 698′.9, which is subtracted from the longitude of the point left because the ship has sailed east,

### EXAMPLE NUMBER 6

One latitude, one longitude, course and departure to find the distance, latitude and longitude in: A ship was sailed S. 67° 30′ W. from a point in latitude 40° 37′ 02″ N. and longitude 69° 37′ 05″ W. making 342′.0 departure. Find the distance, latitude and longitude of the ship.

| | | |
|---|---|---|
| Dep. | 342′.0 | 2.53403 |
| Co. S. 67° 30′ W. | tang. — | .38278 |
| Dif. lat. 2° 21′ 42″ S. | = 141′.7 = | 2.15125 |

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | 40° 37′ 02″ | N. | Long. left | 69° 37′ 05″ | W. |
| Dif. 141′.7 = — | 2 21 42 | S. | Dif. 442′.8 = + | 7 22 48 | W. |
| Lat. ship | 38 15 20 | N. | Long. ship | 76° 59 53 | W. |

| | | |
|---|---|---|
| Dep. | 342′.0 | 2.53403 |
| Co. S. 67° 30′ W. | sin. — | 9.96562 |
| Dist. | 370′.2 = | 2.56841 |

| | | |
|---|---|---|
| Lat. left | 40° 37′ 02″ | N. |
| Lat. ship | + 38 15 20 | N. |
| | 3)78 52 22 | |
| Mid. lat. | 39 26 11 | |

| | | |
|---|---|---|
| Dep. | 342′.0 | 2.53403 |
| Mid. lat. 39° 26′ 11″ | sec. + | .11220 |
| Dif. long. | 7° 22′ 48″ W. = 442′.8 = | 2.64623 |

## EXPLANATION

From the logarithm of the departure 342′.0 subtract the logarithm tangent of the course S. 67° 30′ W., which gives the logarithm of the difference of latitude 141′.7 and is subtracted from the latitude of the point left because the ship has sailed south.

From the logarithm of the departure 342′.0 subtract the logarithm sine of the course S. 67° 30′ W., which gives the logarithm of the distance 370′.2.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude.

To the logarithm of the departure 342′.0 add the logarithm secant of the middle latitude 39° 26′ 11″ and the result will be the logarithm of the difference of longitude 442′.8, which is added to the longitude of the point left because the ship has sailed west and in doing so has increased the longitude.

### EXAMPLE NUMBER 7

One latitude, one longitude, distance and departure to find the course, latitude and longitude in: A ship was sailed 428′.0 to the southward and departure 214′.0 E. from a point in latitude 20° 15′ 00″ N. and longitude 74° 08′ 01″ W. Find the course, latitude and longitude of the ship.

| | | |
|---|---|---|
| Dep. | 214′.0 | 2.33041 |
| Dist. | 428.0 — | 2.63144 |
| Co. S. 30° 00′ E. | = sin. | 9.69897 |

| | | |
|---|---|---|
| Co. S. 30° 00′ E. | cos. | 9.93753 |
| Dist. | 428′.0 + | 2.63144 |
| Dif. lat. 6° 10′ 42″ S. | = 370 .7 = | 2.56897 |

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | 20° 15′ 00″ | N. | Long. left | 74° 08′ 01″ | W. |
| Dif. 370′.7 = — | 6 10 42 | S. | Dif. 224′.0 = — | 3 44 00 | E. |
| Lat. ship | 14 04 18 | N. | Long. ship | 70 24 01 | W. |

| | | |
|---|---|---|
| Lat. left | 20° 15′ 00″ | N. |
| Lat. ship | + 14 04 18 | N. |
| | 2)34 19 18 | |
| Middle lat. | 17 09 39 | |

| | | |
|---|---|---|
| Dep. | 214′.0 | 2.33041 |
| Middle lat. 17° 09′ 39″ | sec. + | .01978 |
| Dif. long. 3° 44′ 00″ E. | = 224′.0 = | 2.35019 |

## EXPLANATION

From the logarithm of the departure 214′.0 subtract the logarithm of the distance 428′.0, which gives the logarithm sine of the course S. 30° E.

To the logarithm cosine of the course S. 30° E. add the logarithm of the distance 428′.0, which gives the logarithm of the difference of latitude 370′.7 and is subtracted from the latitude of the point left because the ship has sailed south.

Add together the latitude of the point left and that of the ship. Then divide by 2, which will give the middle latitude.

To the logarithm of the departure 214′.0 add the logarithm secant of the middle latitude 17° 09′ 39″ and the result will be the logarithm of the difference of longitude 224′.0, which is subtracted from the longitude of the point left because the ship has sailed east and in doing so has decreased the longitude.

### EXAMPLE NUMBER 8

Both latitudes (one north and the other south) and both longitudes to find the course and distance: A ship is in latitude 4° 32′ 45″ N. and longitude 25° 35′ 45″ W. Find the course and distance to a point in latitude 1° 30′ 45″ S. and longitude 24° 05′ 15″ W. Find the course and distance.

| | | | | | |
|---|---|---|---|---|---|
| Lat. ship | 4° 32′ 45″ | N. | Long. ship | 25° 35′ 45″ | W. |
| Lat. point | + 1 30 45 | S. | Long. point | — 24 05 15 | W. |
| Dif. | 363′.5 = 6 03 30 | S. | Dif. | 90′.5 = 1 30 30 | E. |

| | |
|---|---|
| Greater lat. | 2)4° 32′ 45″ |
| Middle lat. | 2 16 22 |

| | | |
|---|---|---|
| Dif. long. | 90′.5 | 1.95665 |
| Mid. lat. 2° 16′ 22″ | cos. + | 9.99966 |
| Dep. | 90′.43 = | 1.95631 |
| Dif. lat. | 363.5 — | 2.56050 |
| Co. S. 13° 58′ E. | = tang. | 9.39581 |
| Co. S. 13° 58′ E. | sec. | .01303 |
| Dif. lat. | 363.5 + | 2.56050 |
| Dist. | 374.6 = | 2.57353 |

This method will satisfy the ordinary demands of practice; but should not be used when the latitudes of the places under consideration lie on opposite sides of the equator. In such cases the course, distance, etc., should be found by Mercator sailing.

## EXPLANATION

Find the difference of latitude by adding the latitude of the point to that of the ship, convert it into miles and name it south because the point is south of the latitude of the ship.

When one latitude is north and the other is south, the middle latitude can best be found by taking half the greater latitude, which has been done in this case, and gives the middle latitude 2° 16′ 22″.

Find the difference of longitude by subtracting the longitude of the point from that of the ship, convert it into miles and name it east because the longitude of the point is east of the longitude of the ship.

To the logarithm of the difference of longitude 90′.5 add the logarithm cosine of the middle latitude 2° 16′ 22″, which gives the logarithm of the departure 90′.43 and from that logarithm subtract the logarithm of the difference of latitude 363′.5 and the result will be the logarithm tangent of the course S. 13° 58′ E.

To the logarithm secant of the course S. 13° 58′ E. add the logarithm of the difference of latitude 363′.5, which gives the logarithm of the distance 374′.6.

When the places under consideration lie so near the equator, it is not necessary to use middle latitude sailing unless requested to do so at an examination, as plain sailing, in which the degrees of latitude and longitude are supposed to be equal, will give a result practically the same.

### EXAMPLE NUMBER 9

Find the course and distance from Sandy Hook light in latitude 40° 27′ 42″ N. and longitude 74° 00′ 09″ W. to Cape of Good Hope light in latitude 34° 21′ 12″ S. and 18° 29′ 26″ E.

| | | | |
|---|---|---|---|
| Lat. Sandy Hook | 40° 27′ 42″ N. | Mer. parts | 2644.2 |
| Lat. Cape G. H. | + 34 21 12 S. | Mer. parts | + 2183.7 |
| Dif. 4488′.9 = | 74 48 54 S. | Dif. | 4827.9 S. |

| | | |
|---|---|---|
| Long. Sandy Hook | | 74° 00′ 09″ W. |
| Long. Cape Good Hope | | + 18 29 26 E. |
| Dif. | 5549′.6 = | 92 29 35 E. |

| | | | |
|---|---|---|---|
| Prop. dif. lat. | 4488′.9 | | 3.65215 |
| Mer. dif. | 4827.9 | — | 3.68377 |
| Middle lat. 21° 36′ | = cos. | | 9.96838 |
| Dif. long. | 5549′.6 | | 3.74429 |
| Mid. lat. 21° 36′ | cos. | + | 9.96838 |
| | | | 3.71267 |
| Prop. dif. lat. | 4488′.9 | — | 3.65215 |
| Co. S. 48° 58′ E. | = tang. | | 0.06052 |
| Co. S. 48° 59′ E. | sec. | | .18291 |
| Prop. dif. lat. | 4488′.9 | + | 3.65215 |
| Dist. | 6840.0 | = | 3.83506 |

## EXPLANATION

Find the difference of latitude by adding the latitude of Cape of Good Hope to that of Sandy Hook, convert it into miles and name it south because Cape of Good Hope is south of the latitude of Sandy Hook.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference by adding, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Find the difference of longitude by adding the longitude of Cape of Good Hope to that of Sandy Hook, convert it into miles and name it east because Cape of Good Hope is east of the longitude of Sandy Hook.

When the places under consideration are on opposite sides of the equator, the middle latitude should not be found in the usual manner, if an accurate result is required.

From the logarithm of the proper difference of latitude 4488′.9 subtract the logarithm of the meridional difference of latitude

4827′.9, which gives the logarithm cosine of the middle latitude 21° 36′. By using the middle latitude found in this manner, the course and distance found by middle latitude sailing will be exactly the same as by Mercator sailing.

To the logarithm of the difference of longitude 5549′.6 add the logarithm cosine of the middle latitude 21° 36′ and from the resulting logarithm subtract the logarithm of the proper difference of latitude 4488′.9, which gives the logarithm tangent of the course S. 48° 59′ E.

To the logarithm secant of the course S. 48° 59′ E. add the logarithm of the proper difference of latitude 4488′.9, which gives the logarithm of the distance 6840′.0.

### EXAMPLE NUMBER 10

Find the course and distance from Cape Horn in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to Cape of Good Hope in latitude 34° 21′ 12″ S. and longitude 18° 29′ 26″. E.

| | | | |
|---|---|---|---|
| Lat. Cape Horn | 55° 58′ 41″ S. | Mer. parts | 4052′.7 |
| Lat. Cape G. H. | —34 21 12 S. | Mer. parts | —2183 .7 |
| Dif. | 1297′.5 = 21 37 29 N. | Dif. | 1869 .0 N. |

| | | |
|---|---|---|
| Long. Cape Horn | 67° 16′ 15″ | W. |
| Long. Cape G. H. | + 18 29 26 | E. |
| Dif. | 5145′.7 = 85 45 41 | E. |

| | | |
|---|---|---|
| Prop. dif. lat. | 1297′.5 | 3.11311 |
| Mer. dif. lat. | 1869 .0 — | 3.27161 |
| Middle lat. 46° 02′ | = cos. | 9.84150 |
| Dif. long. | 5145 .7 | 3.71145 |
| Middle lat. 46° 02′ | = cos. | 9.84150 |
| | | 3.55295 |
| Prop. dif. lat. | 1297′.5 — | 3.11311 |
| Co. N. 70° 02′ E. | = tang. | 0.43984 |
| Co. N. 70° 02′ E. | sec. | .46664 |
| Prop. dif. lat. | 1297′.5 + | 3.11311 |
| Dist. | 3799 .7 = | 3.57975 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of Cape of Good Hope from that of Cape Horn, convert it into miles and name it north because Cape of Good Hope is north of Cape Horn.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Find the difference of longitude by adding the longitude of Cape of Good Hope to that of Cape Horn, convert it into miles and name it east because Cape of Good Hope is east of the longitude of Cape Horn.

The middle latitude should not be found in the usual manner, if an accurate result is required.

From the logarithm of the proper difference of latitude 1297'.5 subtract the logarithm of the meridional difference of latitude 1869'.0, which gives the logarithm cosine of the middle latitude 46° 02'.

To the logarithm of the difference of longitude 5145'.7 add the logarithm cosine of the middle latitude 46° 02' and from the resulting logarithm subtract the logarithm of the proper difference of latitude 1297'.5, which gives the logarithm tangent of the course N. 70° 02' E.

The logarithm secant of the course N. 70° 02' E. add the logarithm of the proper difference of latitude 1297'.5 and the result will be the logarithm of the distance 3799'.7.

### EXAMPLE NUMBER II

Find the course and distance from Cape Horn in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to Sydney, Australia, in latitude 33° 51′ 41″ S. and longitude 151° 12′ 23″ E.

| | | | | | |
|---|---|---|---|---|---|
| Lat. Cape Horn | | 55° 58′ 41″ | S. | Mer. parts | 4052′.7 |
| Lat. Sydney | | — 33 51 41 | S. | Mer. parts | — 2148.8 |
| Dif. | 1327′.0 = | 22 07 00 | N. | Dif. | 1903.9 N. |

| | | | |
|---|---|---|---|
| Long. Cape Horn | | 67° 16′ 15″ | W. |
| Long. Sydney | | + 151 12 23 | E. |
| Dif. | | — 218 28 38 | E. |
| | | 360 00 00 | |
| Dif. | 8491′.4 = | 141 31 22 | W. |

| | | |
|---|---|---|
| Prop. dif. lat. | 1327′.0 | 3.12287 |
| Mer. dif. | 1903.9 — | 3.27965 |
| Middle lat. 45° 49′ | = cos. | 9.84322 |
| Dif. long. | 8491.4 | 3.92898 |
| Mid. lat. 45° 49′ | cos. + | 9.84322 |
| | | 3.77220 |
| Prop. dif. lat. | 1327′.0 — | 3.12287 |
| Co. N. 77° 22′ W. | = tang. | 0.64933 |
| Co. N. 77° 22′ W. | sec. | .66013 |
| Prop. dif. lat. | 1327′.0 + | 3.12287 |
| **Dist.** | 6067.4 = | 3.78300 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of Sydney from that of Cape Horn, convert it into miles and name it north because Sydney is north of Cape Horn.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

To the longitude of Cape Horn add the longitude of Sydney because they are of different name and the result will be the difference of longitude east, and as it is greater than 180°, it is subtracted from 360° and gives the difference of longitude 8491′.4 W.

The middle latitude should not be found in the usual manner, if an accurate result is required.

From the logarithm of the proper difference of latitude 1327′.0 subtract the logarithm of the meridional difference of latitude 1903′.9, which gives the logarithm cosine of the middle latitude 45° 49′.

To the logarithm of the difference of longitude 8491′.4 add the logarithm cosine of the middle latitude 45° 40′ and from the resulting logarithm subtract the logarithm of the proper difference of latitude 1327′.0, which gives the logarithm tangent of the course N. 77° 22′ W.

To the logarithm secant of the course N. 77° 22′ W. add the logarithm of the proper difference of latitude 1327′.0, which gives the logarithm of the distance 6067′.4.

## MERCATOR SAILING BY INSPECTION

Having the latitudes and longitudes of the two points between which the course and distance are wanted, find their differences and name the difference of latitude north or south and the difference of longitude east or west, according to the direction of the point to which the course and distance is to be found.

From Table 3 take the meridional parts for each latitude to the nearest mile and find their difference, which takes the same name given the proper difference of latitude.

Enter Table 2 with the meridional difference of latitude and difference of longitude and the course will be found where they agree nearest, the meridional difference of latitude in the latitude column and the difference of longitude in the departure column. If the meridional difference is the greater, the course will be at the top of the page, and if the difference of longitude is the greater, the course will be found at the bottom of the page; but in any case they do not give the distance.

The distance will be found in the distance column opposite the proper difference of latitude in the latitude column under the same degree where the course is found, taking care to read from the same end of the page, top or bottom, from which the course was taken.

### EXAMPLE NUMBER I

Both latitudes and longitudes to find the course and distance: A ship is in latitude 36° 51′ 00″ N. and longitude 70° 55′ 45″ W. Find the course and distance to Barnegat light in latitude 39° 45′ 52″ N. and longitude 74° 06′ 24″ W.

| | | | |
|---|---|---|---|
| Lat. ship | —36° 51′ 00″ N. | Mer. parts | — 2367′.3 |
| Lat. Barnegat | 39 45 52 N. | Mer. parts | 2589.5 |
| Dif. 174′.9 = | 2 54 52 N. | Dif. | 222.2 N. |

| | |
|---|---|
| Long. ship | —70° 55′ 45″ W. |
| Long. Barnegat | 74 06 24 W. |
| Dif. 190′.65 = | 3 10 39 W. |

$$\left.\begin{array}{l}\text{Mer. dif. } 222'.2\text{ N.}\\ \text{Dif. long. } 190.6\text{ W.}\end{array}\right\} = \text{Co. N. } 41^\circ\text{ W.}$$

$$\left.\begin{array}{l}\text{Co. N. } 41^\circ\text{ W.}\\ \text{Prop. dif. lat. } 174'.9\end{array}\right\} = \text{Distance } 232'.0.$$

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of Barnegat light, convert it into miles and name it north because Barnegat light is north of the latitude of the ship.

Find the difference of longitude by subtracting the longitude of the ship from that of Barnegat light, convert it into miles and name it west because Barnegat light is west of the longitude of the ship.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Enter Table 2 with the meridional difference of latitude 222′.2 N. and the difference of longitude 190′.6 W. and where they are found to agree nearly, the meridional difference in the latitude column and the difference of longitude in the departure column will give the course N. 41° W.

The course N. 41° W. and the proper difference of latitude 174′.9 in the latitude column will give the distance 232′.0.

### EXAMPLE NUMBER 2

Both latitudes, one longitude and departure to find the course and distance, and longitude in: A ship left a point in latitude 37° 55′ 25″ N. and longitude 74° 56′ 22″ W. and arrived in latitude 35° 57′ 25″ N., the departure being 216′.5 E. Find the course and distance and longitude of the ship.

| | | | | |
|---|---|---|---|---|
| Lat. point | | 37° 55′ 25″ N. | Mer. parts | 2447′.5 |
| Lat. ship. | | —35 57 25 N. | Mer. parts | — 2300 .5 |
| Dif. | 118′.0 = | 1 58 00 S. | Dif. | 147 .0 S. |

$$\left.\begin{array}{ll}\text{Proper. dif. lat.} & 118'.0\text{ S.}\\ \text{Dep.} & 216.5\text{ E.}\end{array}\right\} = \text{Co. S. } 61^\circ\ 30'\text{ E.}$$

$$\left.\begin{array}{l}\text{Co. S. } 61^\circ\ 30'\text{ E.}\\ \text{Mer. dif. lat. } 147'.0\end{array}\right\} = \text{dif. long. } 270'.6\text{ E.}$$

| | | |
|---|---|---|
| Long. point | | 74° 56′ 22″ W. |
| Dif. 270′.6 E. | = — | 4 30 36 E. |
| Long. ship | | 70 25 46 W. |

$$\left.\begin{array}{l}\text{Co. S. } 61^\circ\ 30'\text{ E.}\\ \text{Prop. dif. lat. } 118'.0\end{array}\right\} = \text{Distance } 247'.0.$$

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of the point left, convert it into miles and name it south because it is south of the point sailed from.

From Table 3 take the meridional parts to the nearest mile of latitude and take their difference, which takes the same name as the proper difference of latitude.

Enter Table 2 with the proper difference of latitude 118′.0 S. and departure 216′.5 E. and where they agree nearly, the course

S. 61° 30′ E. will be found and is taken from the bottom of the page because the departure is greater than the proper difference of latitude.

With the course S. 61° 30′ E. in Table 2 find the meridional difference of latitude 147′.0 in the latitude column, reading from the bottom, and the difference of longitude will be found in the departure column.

Subtract the difference of longitude 270′.6 E. from the longitude of the point left and the result will be the longitude of the ship.

Enter Table 2 with the course S. 61° 30′ E. and find the proper difference of latitude 118′.0 in the latitude column and the distance 247′.0 will be found opposite in the distance column.

### EXAMPLE NUMBER 3

One latitude, one longitude, course and distance to find the latitude and longitude of the ship: A ship sailed S. 65° E. for 362′.0 from a point in latitude 35° 15′ 17″ N. and longitude 75° 31′ 16″ W. Find the latitude and longitude in.

$$\left.\begin{array}{l}\text{Co. S. }65^\circ\text{ E.}\\ \text{Distance }362'.0\end{array}\right\} = \text{dif. lat. }153'.0\text{ S.}$$

| | | | | |
|---|---|---|---|---|
| Lat. left | 35° 15′ 17″ | N. | Mer. parts | 2249′.1 |
| Dif. 153′.0 = — | 2 33 00 | S. | | |
| Lat. ship. | 32 42 17 | N. | Mer. parts | — 2065 .5 |
| | | | Dif. | 183 .6 S. |

$$\left.\begin{array}{l}\text{Co. S. }65^\circ\text{ E.}\\ \text{Mer. dif. lat. }183'.6\text{ S.}\end{array}\right\} = \text{Dif. long. }393'.7\text{ E.}$$

| | | |
|---|---|---|
| Long. left | 75° 31′ 16″ | W. |
| Dif. 392′.4 E. = — | 96 33 42 | E. |
| Long. ship | 68 58 34 | W. |

## EXPLANATION

Enter Table 2 with the course S. 65° E. and distance 362'.0 in the distance column and the corresponding number in the latitude column 153'.0 will be the proper difference of latitude, which subtracted from the latitude left gives the latitude of the ship.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

With the course S. 65° E. and the meridional difference of latitude 183'.6 S. enter Table 2 and find the meridional difference of latitude in the latitude column and the difference of longitude 393'.7 will be opposite in the departure column, which subtracted from the longitude left gives the longitude of the ship.

### EXAMPLE NUMBER 4

Both latitudes, one longitude and course to find the distance and longitude in: A ship was sailed S. 56° W. from a point in latitude 34° 21' 12" S. and longitude 18° 29' 26" E. to latitude 37° 10' 25" S. Find the distance and longitude of the ship.

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | | —34° 21' 12" | S. | Mer. parts | — 2183'.7 |
| Lat. ship | | 37 10 25 | S. | Mer. parts | 2391 .0 |
| Dif. | 169'.2 = | 2 49 13 | S. | Dif. | 207 .3 S. |

$\left.\begin{array}{l}\text{Co. S. } 56^\circ \text{ W.}\\ \text{Mer. dif. } 207'.3 \text{ S.}\end{array}\right\} = \text{dif. long. } 307'.6$

| | | | |
|---|---|---|---|
| Long. left | | 18° 29' 26" | E. |
| Dif. long. | 307'.6 = — | 5 07 36 | W. |
| Long. ship | | 13 21 50 | E. |

$\left.\begin{array}{l}\text{Co. S. } 56^\circ \text{ W.}\\ \text{Prop. dif. lat. } 169'.2 \text{ S.}\end{array}\right\} = \text{distance } 302'.5.$

## EXPLANATION

Find the difference of latitude by subtracting the latitude left from that of the ship and name it south because the ship is south of the point left.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Enter Table 2 with the course S. 56° W. and meridional difference of latitude 207′.3 S. and the corresponding number in the departure column 307′.6 will be the difference of longitude, which subtracted from the longitude left gives the longitude of the ship.

Enter Table 2 with the course S. 56° W. and find the proper difference of latitude 169′.2 in the latitude column and the corresponding number in the distance column 302′.5 will be the distance.

### EXAMPLE NUMBER 5

Both latitudes, one longitude and distance to find the course and longitude in: A ship was sailed 392′.0 easterly from a point in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to latitude 57° 05′ 30″ S. Find the course, latitude and longitude of the ship.

| | | | | | |
|---|---|---|---|---|---|
| Lat. left | | —55° 58′ 41″ | S. | Mer. parts | — 4052′.7 |
| Lat. ship | | 57 05 30 | S. | Mer. parts | 4173 .0 |
| Dif. | 66′.8 = | 1 06 49 | S. | Dif. | 120 .3 |

$$\left.\begin{array}{ll}\text{Prop. dif. lat.} & 66'.8\text{ S.}\\ \text{Dist.} & 392.0\text{ E.}\end{array}\right\} = \text{Co. S. } 80^\circ\text{ E.}$$

$$\left.\begin{array}{ll}\text{Co. S. } 80^\circ\text{ E.} & \\ \text{Mer. dif.} & 120'.3\end{array}\right\} = \text{Dif. long. } 681'.4\text{ E.}$$

| | | | |
|---|---|---|---|
| Long. left | | 67° 16′ 15″ | W. |
| Dif. | 681′.4 = | — 11 21 24 | E. |
| Long. ship | | 55 54 51 | W. |

## EXPLANATION

Find the difference of latitude by subtracting the latitude left from that of the ship and name it south because the ship is south of the point left.

From Table 3 take the meridional parts for both latitudes and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Enter Table 2 with the proper difference of latitude 66′.8 S. in the latitude column and where it agrees with the distance 392′.0 E. in the distance column will be found the course S. 80° E.

Enter Table 2 with the course S. 80° E. and the meridional difference of latitude 120′.3 in the latitude column and the corresponding number in the departure column will be the difference of longitude 681′.4 E., which subtracted from the longitude left gives the longitude of the ship.

In this example the error of 13′.9 in the difference of longitude is due to the difference of 11′.0 between the course found by logarithms and that by inspection, and shows that logarithms should be used if an accurate result is wanted, and particularly so when the elements fall beyond the limits of Table 2.

### EXAMPLE NUMBER 6

One latitude, one longitude, course and departure to find the distance, latitude and longitude in: A ship was sailed S. 67° 30′ W. from a point in latitude 40° 37′ 02″ N. and longitude 69° 37′ 05″ W. making 342′.0 departure. Find the distance, latitude and longitude of the ship.

$$\left.\begin{array}{l}\text{Co. S. } 67^\circ\ 30' \text{ W.}\\ \text{Dep. } 342'.0 \text{ W.}\end{array}\right\} = \text{Dif. lat. } 141'.8.$$

| | | | |
|---|---|---|---|
| Lat. left | 40° 37′ 02″ N. | Mer. parts | 2656′.0 |
| Dif. 141′.8 = — | 2 21 48 S. | | |
| Lat. ship | 38 15 14 N. | Mer. parts | — 2472.8 |
| | | Dif. | 183.2 S. |

$$\left.\begin{array}{l}\text{Co. S. } 67^\circ\ 30' \text{ W.}\\ \text{Mer. dif. } 183'.2\end{array}\right\} = \text{dif. long. } 442'.5 \text{ W.}$$

| | | |
|---|---|---|
| Long. left. | 69° 37′ 05″ | W. |
| Dif. 442′.5 = + | 7 22 30 | W. |
| Long. ship | 76 59 35 | W. |

$$\left.\begin{array}{l}\text{Co. S. } 67^\circ\ 30' \text{ W.}\\ \text{Prop. dif. lat. } 141'.8 \text{ S.}\end{array}\right\} = \text{distance } 370'.0.$$

## EXPLANATION

Enter Table 2 with the course S. 67° 30′ W. and find the departure 342′.0 W. with 67° and the corresponding number in the latitude column will be the difference of latitude. Using 68°, find the difference of latitude in the same manner and add together and divide by 2 and the result will be the proper difference of latitude 141′.8 S., which is subtracted from the latitude left because the ship has sailed south, and gives the latitude of the ship.

From Table 3 take the meridional parts for both latitudes and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Enter Table 2 with the course 67° and 68° and the meridional difference of latitude 183′.2 in the latitude column and the mean of the corresponding numbers in the departure columns will be the difference of longitude 442′.5 W., which is added to the longitude left, giving the longitude of the ship.

With the courses 67° and 68° find the proper difference of latitude 141′.8 in the latitude columns and the mean of the corresponding numbers in the distance columns 370′.0 will be the distance.

### EXAMPLE NUMBER 7

One latitude, one longitude, distance and departure to find the course, latitude and longitude in: A ship was sailed 428'.0 to the southward and departure 214'.0 E. from a point in latitude 20° 15' 00" N. and longitude 74° 08' 01" W. Find the course, latitude and longitude of the ship.

$$\left.\begin{array}{ll}\text{Dist.} & 428'.0\ \text{S.}\\ \text{Dep.} & 214\ .0\ \text{E.}\end{array}\right\} = \left\{\begin{array}{l}\text{Prop. dif. lat. } 370'.7\ \text{S.}\\ \text{Co. S. } 30^\circ\ \text{E.}\end{array}\right.$$

Lat. left 20° 15' 00" N. Mer. parts 1233 0
Dif. 370'.7 = — 6 10 42 S.
Lat. ship 14 04 18 N. Mer. parts — 846 .9
Dif. 386 .1 S.

$$\left.\begin{array}{l}\text{Co. S. } 30^\circ\ \text{E.}\\ \text{Mer. dif. lat. } 386'.1\end{array}\right\} = \text{dif. long. } 223'.0\ \text{E.}$$

Long. left 74° 08' 01" W.
Dif. 223'.0 = — 3 43 00 E.
Long. ship 70 25 01 W.

## EXPLANATION

Enter Table 2 with the distance 428'.0 S. and the departure 214'.0 E. and where they agree, the proper difference of latitude 370'.7 and the course S. 30° E. will be found.

Subtract the proper difference of latitude 370'.7 from the latitude left and the result will be the latitude of the ship.

From Table 3 take the meridional parts for both latitudes and find their difference, which takes the same name as the proper difference of latitude.

Enter Table 2 with the course S. 30° E. and find the meridional difference of latitude 386'.1 in the latitude column and the corresponding number in the departure column will be the difference of longitude 223'.0 E., which subtracted from the longitude left gives the longitude of the ship.

### EXAMPLE NUMBER 8

Both latitudes (one north and the other south) and both longitudes to find the course and distance: A ship is in latitude 4° 32′ 45″ N. and longitude 25° 35′ 45″ W. Find the course and distance to a point in latitude 1° 30′ 45″ S. and longitude 24° 05′ 15″ W.

| | | | | |
|---|---|---|---|---|
| Lat. ship | 4° 32′ 45″ | N. | Mer. parts | 271′.4 |
| Lat. point | + 1 30 45 | S. | Mer. parts | + 90 .4 |
| Dif. | 363′.5 = 6 03 30 | S. | Dif. | 361 .8 |

| | | |
|---|---|---|
| Long. left | 25° 35′ 45″ | W. |
| Long. point | — 24 05 15 | W. |
| Dif. | 90′.5 = 1 30 30 | E. |

$$\left.\begin{array}{lll}\text{Mer. dif.} & 361'.8 & \text{S.}\\ \text{Dif. long.} & 90.5 & \text{E.}\end{array}\right\} = \text{Co. S. } 14^\circ \text{ E.}$$

$$\left.\begin{array}{ll}\text{Co. S. } 14^\circ \text{ E.} & \\ \text{Prop. dif. lat.} & 363'.5\end{array}\right\} = \text{Distance } 374'.7.$$

## EXPLANATION

Find the difference of latitude by adding the latitude of the point to that of the ship, convert it into miles and name it south, because the point is south of the latitude of the ship.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference by adding, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Find the difference of longitude by subtracting the longitude of the point from that of the ship, convert it into miles and name it east, because the point is east of the longitude of the ship.

Enter Table 2 with the meridional difference of latitude 361′.8 S. and the difference of longitude 90′.5 E. and where they are found to agree nearly, the meridional difference in the latitude column and the difference of longitude in the departure column will give the course S. 14° E.

Enter Table 2 with the course S. 14° E. and find the proper difference of latitude 363′.5 in the latitude column. The distance 374′.7 is found opposite in the distance column.

When the places under consideration lie so near the equator it is not necessary to use Mercator sailing unless requested to do so at an examination, as plain sailing, in which the degrees of latitude and longitude are supposed to be equal, will give a result practically the same.

# MERCATOR SAILING BY LOGARITHMS

The course, distance, etc., found by inspection should not be used unless the distance is small and an approximate result will answer. Its most frequent use is in finding the course and distance made good from noon to noon, which should be exact. However, in any case, the elements wanted should be found by inspection first, which not only serves as a check, but saves time in selecting logarithms from Tables 42 and 44.

A general description of the various operations is not given here, but in its place an individual explanation follows each example.

The following table contains the necessary rules for the solution of any problem by Mercator sailing:

| Ex. | Given. | To Find. | Methods. |
|---|---|---|---|
| 1 | Both lats. and longs. | Co.<br>Dist.<br>Dep. | Tang. co. = dif. long. ÷ mer. dif. lat.<br>Dist. = sec. co. × prop. dif. lat.<br>Dist. = prop. dif. lat. ÷ cos. co.<br>Dep. = prop. dif. lat. × tang. co.<br>Dep. = (prop. dif. lat. × dif. long.) ÷ mer. dif. lat. |
| 2 | Both lats. and dep. | Co.<br>Dist.<br>Dif. long. | Tang. co. = dep. ÷ prop. dif. lat.<br>Dist. = prop. dif. lat. × sec. co.<br>Dist. = dep. ÷ sin. co.<br>Dif. long. = mer. dif. lat. × tang. co.<br>Dif. long. = (dep. × mer. dif. lat.) ÷ prop. dif. lat. |
| 3 | One lat. co. and dist. | Dep.<br>Prop. dif. lat.<br>Dif. long. | Dep. = dist. × sin. co.<br>Prop. dif. lat. = dist. × cos co.<br>Dif. long. = mer. dif. lat. × tang. co. |
| 4 | Both lats. and co. | Dist.<br>Dep.<br>Dif. long. | Dist. = prop. dif. lat. ÷ cos. co.<br>Dep. = prop. dif. lat. × tang. co.<br>Dif. long. = mer. dif. lat. × tang. co. |
| 5 | Both lats. and dist. | Co.<br>Dep.<br>Dif. long. | Cos. co. = prop. dif. lat. ÷ dist.<br>Dep. = dist. × sin. co.<br>Dif. long. = mer. dif. lat. × tang. co. |
| 6 | One lat. co. and dep. | Prop. dif. lat.<br>Dist.<br>Dif. long. | Prop. dif. lat. = dep. ÷ tang. co.<br>Dist. = dep. ÷ sin.co.<br>Dif. long. = mer. dif. lat. × tang. co.<br>Dif. long. = (dep. × mer. dif. lat.) ÷ prop. dif. lat. |
| 7 | One lat. dist. and dep. | Co.<br>Prop. dif. lat.<br>Dif. long. | Sin. co. = dep. ÷ dist.<br>Prop. dif. lat. = dist. × cos. co.<br>Dif. long. = mer. dif. lat. × tang. co.<br>Dif. long. = (dep. × mer. dif. lat.) ÷ prop. dif. lat. |

### EXAMPLE NUMBER I

Both latitudes and longitudes to find the course and distance: A ship is in latitude 36° 51′ 00″ N. and longitude 70° 55′ 45″ W. Find the course and distance to Barnegat light in latitude 39° 45′ 52″ N. and longitude 74° 06′ 24″ W.

| | | | | |
|---|---|---|---|---|
| Lat. ship | | —36° 51′ 00″ N. | Mer. parts | — 2367′.3 |
| Lat. Barnegat | | 39 45 52 N. | Mer. parts | 2589.5 |
| Dif. | 174′.9 = | 2 54 52 N. | Dif. | 222.2 N. |

| | | |
|---|---|---|
| Long. ship | | —70° 55′ 45″ W. |
| Long. Barnegat | | 74 06 24 W. |
| Dif. | 190′.6 = | 3 10 39 W. |

| | | | |
|---|---|---|---|
| Dif. long. | 190′.6 W. | | 2.28012 |
| Mer. dif. | 222.2 N. | — | 2.34674 |
| Co. N. 40° 37′ W. | = tang. | | 9.93338 |
| Co. N. 40° 37′ W. | sec. | | .11971 |
| Prop. dif. lat. | 174′.9 | + | 2.24279 |
| Dist. | 230′.4 | = | 2.36250 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of Barnegat light, convert it into miles and name it north, because the point is north of the latitude of the ship.

Find the difference of longitude by subtracting the longitude of the ship from that of Barnegat light, convert it into miles and name it west, because Barnegat light is west of the longitude of the ship.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

From the logarithm of the difference of longitude 190′.6 W. subtract the logarithm of the meridional difference of latitude 222′.2 N., which gives the logarithm tangent of the course N. 40° 37′ W.

To the logarithm secant of the course N. 40° 37′ W. add the logarithm of the proper difference of latitude 174′.9, which gives the logarithm of the distance 230′.4.

### EXAMPLE NUMBER 2

Both latitudes, one longitude and departure to find the course and distance, and longitude in: A ship left a point in latitude 37° 55′ 25″ N. and longitude 74° 56′ 22″ W. and arrived in latitude 35° 57′ 25″ N., the departure being 216′.5 E. Find the course and distance and longitude of the ship.

| | | | |
|---|---|---|---|
| Lat. point | 37° 55′ 25″ N. | Mer. parts | 2447′.5 |
| Lat. ship | — 35 57 25 N. | Mer. parts | — 2300 .5 |
| Dif. 118′.0 = | 1 58 00 S. | Dif. | 147 .0 S. |

| | | |
|---|---|---|
| Dep. | 216′.5 E. | 2.33546 |
| Prop. dif. lat. | 118 .0 S. — | 2.07188 |
| Co. S. 61° 24′ E. | = tang. | 0.26358 |

| | | |
|---|---|---|
| Prop. dif. lat. | 118′.0 | 2.07188 |
| Co. S. 61° 24′ E. | sec. + | .31994 |
| Dist. | 246′.5 | 2.39182 |

| | | |
|---|---|---|
| Mer. dif. | 147′.0 | 2.16732 |
| Co. S. 61° 24′ E. | tang. + | .26358 |
| Dif. long. | 4° 29′ 42″ E. = 269′.7 | = 2.43090 |

| | |
|---|---|
| Long point | 74° 56′ 22″ W. |
| Dif. 269′.7 = — | 4 29 42 E. |
| Long. ship | 70 26 40 W. |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the ship from that of the point left, convert it into miles and name it south, because the ship is south of the point sailed from.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

From the logarithm of the departure 216′.5 E. subtract the logarithm of the proper difference of latitude 118′.0 S., which gives the logarithm tangent of the course S. 61° 24′ E.

To the logarithm of the proper difference of latitude 118′.0 add the logarithm secant of the course S. 61° 24′ E., which gives the logarithm of the distance 246′.5.

To the logarithm of the meridional difference of latitude 147'.0 add the logarithm tangent of the course S. 61° 24' E., which gives the logarithm of the difference of longitude 269'.7, which is subtracted from the longitude of the point sailed from and gives the longitude of the ship.

### EXAMPLE NUMBER 3

One latitude, one longitude, course and distance to find the latitude and longitude of the ship: A ship sailed S. 65° E. for 362'.0 from a point in latitude 35° 15' 17" N. and longitude 75° 31' 16" W. Find the latitude and longitude in.

| | | | |
|---|---|---|---|
| Dist. | | 362'.0 | 2.55871 |
| Co. S. 65° E. | | cos. + | 9.62595 |
| Prop. dif. lat. | 2° 33' 00" S. = | 153'.0 = | 2.18466 |

| | | | | |
|---|---|---|---|---|
| Lat. left | | 35° 15' 17" N. | Mer. parts | 2249'.1 |
| Dif. | 153'.0 = | — 2 33 00 S. | | |
| Lat. ship | | 32 42 17 N. | Mer. parts | — 2065.5 |
| | | | Dif. | 183 .6 S. |

| | | | |
|---|---|---|---|
| Mer. dif. | | 183'.6 | 2.26387 |
| Co. S. 65° E. | | tang. + | .33133 |
| Dif. long. | 6° 33' 42" E. = | 393'.7 = | 2.59520 |

| | | |
|---|---|---|
| Long. left | | 75° 31' 16" W. |
| Dif. | 393'.7 — | 6 33 42 E. |
| Long. ship | | 68 57 34 W. |

## EXPLANATION

To the logarithm of the distance 362′.0 add the logarithm cosine of the course S. 65° E., which gives the logarithm of the proper difference of latitude 153′.0.

From the latitude left subtract the difference of latitude 153′.0, which gives the latitude of the ship.

From Table 3 take the meridional parts for both latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

To the logarithm of the meridional difference of latitude 183′.6 add the logarithm tangent of the course S. 65° E., which gives the logarithm of the difference of longitude 393′.7 E., which subtracted from the longitude left will give the longitude of the ship.

### EXAMPLE NUMBER 4

Both latitudes, one longitude and course to find the distance and longitude in: A ship was sailed S. 56° W. from a point in latitude 34° 21′ 12″ S. and longitude 18° 29′ 26″ E. to latitude 37° 10′ 25″ S. Find the distance and longitude of the ship.

| | | | | |
|---|---|---|---|---|
| Lat. left | | — 34° 21′ 12″ S. | Mer. parts | — 2183′.7 |
| Lat. ship | | 37 10 25 S. | Mer. parts | 2391 .0 |
| Dif. | 169′.2 = | 2 49 13 S. | Dif. | 207 .3 S. |

| | | | | |
|---|---|---|---|---|
| Mer. dif. | | 207′.3 | | 2.31660 |
| Co. S. 56° W. | | tang | + | .17101 |
| Dif. long. | 5° 07′ 18″ W. = | 307′.3 | = | 2.48761 |

| | | |
|---|---|---|
| Long. left | | 18° 29′ 26″ E. |
| Dif. 307′.3 = | — | 5 07 18 W. |
| Long. ship | | 13 22 08 E. |

| | | | |
|---|---|---|---|
| Prop. dif. lat. | 169′.2 | | 2.22840 |
| Co. S. 56° W. | cos. | — | 9.74756 |
| Dist. | 302′.6 | = | 2.48084 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude left from that of the ship, convert it into miles and name it south, because the ship has sailed south.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

To the logarithm of the meridional difference of latitude 207′.3 add the logarithm tangent of the course S. 56° W. and the result will be the difference of longitude 307′.3 W., which is subtracted from the longitude left and gives the longitude of the ship.

From the logarithm of the proper difference of latitude 169′.2 subtract the logarithm cosine of the course S. 56° W., which gives the logarithm of the distance 302′.6.

### EXAMPLE NUMBER 5

Both latitudes, one longitude and distance to find the course and longitude in: A ship was sailed 392′.0 easterly from a point in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to latitude 57° 05′ 30″ S. Find the course, latitude and longitude of the ship.

| | | | | |
|---|---|---|---|---|
| Lat. left | | —55° 58′ 41″ S. | Mer. parts | —4052′.7 |
| Lat. ship | | 57 05 30 S. | Mer. parts | 4173 .0 |
| Dif. | 66′.8 = | 1 06 49 S. | Dif. | 120 .3 S. |

| | | | |
|---|---|---|---|
| Prop. dif. lat. | | 66′.8 S. | 1.82478 |
| Dist. | | 392 .0 E. | — 2.59329 |
| Co. S. 80° 11′ E. | | = cos. | 9.23149 |
| Mer. dif. | | 120′.3 | 2.08027 |
| Co. S. 80° 11′ E. | | tang. | + .76188 |
| Dif. long. | 11° 35′ 18″ E. | = 695′.3 | = 2.84215 |

| | | |
|---|---|---|
| Long. left | | 67° 16′ 15″ W. |
| Dif. | 695′.3 = | —11 35 18 E. |
| Long. ship | | 55 40 57 W. |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of the point left from that of the ship, convert it into miles and name it south, because the ship has sailed south.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

From the logarithm of the proper difference of latitude 66′.8 subtract the logarithm of the distance 392′.0 and the result will be the logarithm cosine of the course S. 80° 11′ E.

To the logarithm of the meridional difference of latitude 120′.3 add the logarithm tangent of the course S. 80° 11′ E. and the result will be the logarithm of the difference of longitude 695′.3 E., which is subtracted from the longitude left and gives the longitude of the ship.

### EXAMPLE NUMBER 6

One latitude, one longitude, course and departure to find the distance, latitude and longitude in: A ship was sailed S. 67° 30′ W. from a point in latitude 40° 37′ 02″ N. and longitude 69° 37′ 05″ W., making 342′.0 departure. Find the distance, latitude and longitude of the ship.

| | | |
|---|---|---|
| Dep. | 342'.0 | 2.53403 |
| Co. S. 67° 30' W. | tang. — | .38278 |
| Prop. dif. lat. | 2° 21' 42" S. = 141'.7 = | 2.15125 |

| | | | | |
|---|---|---|---|---|
| Lat. left | | 40° 37' 02" N. | Mer. parts | 2656'.0 |
| Dif. | 141'.7 = — | 2 21 42 S. | | |
| Lat. ship | | 38 15 20 N. | Mer. parts | —2472.8 |
| | | | Dif. | 183.2 S. |

| | | |
|---|---|---|
| Mer. dif. | 183'.2 | 2.26293 |
| Co. S. 67° 30' W. | tang. — | .38278 |
| Dif. long. | 7° 22' 18" W. = 442'.3 = | 2.64571 |

| | | |
|---|---|---|
| Long. left | | 69° 37' 05" W. |
| Dif. | 442'.3 = + | 7 22 18 W. |
| Long. ship | | 76 59 23 W. |

| | | |
|---|---|---|
| Co. S. 67° 30' W. | sec. | .41716 |
| Prop. dif. lat. | 141'.7 + | 2.15125 |
| Dist. | 370.2 = | 2.56841 |

## EXPLANATION

From the logarithm of the departure 342'.0 subtract the logarithm tangent of the course S. 67° 30' W., which gives the logarithm of the proper difference of latitude 141'.7.

From the latitude left subtract the proper difference of latitude 141'.7, which gives the latitude of the ship.

From Table 3 take the meridional parts for both latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

To the logarithm of the meridional difference of latitude 183'.2 S. add the logarithm tangent of the course S. 67° 30' W. and the result will be the logarithm of the difference of longitude 442'.3, which is added to the longitude left and gives the longitude of the ship.

To the logarithm secant of the course S. 67° 30' W. add the logarithm of the proper difference of latitude 141'.7, which gives the logarithm of the distance 370'.2.

### EXAMPLE NUMBER 7

One latitude, one longitude, distance and departure to find the course, latitude and longitude in: A ship was sailed 428'.0 to the southward and made a departure 214'.0 east from a point in latitude 20° 15' 00" N. and longitude 74° 08' 01" W. Find the course, latitude and longitude of the ship.

| | | |
|---|---|---|
| Dep. | 214'.0 E. | 2.23041 |
| Dist. | 428.0 S. | —2.63144 |
| Co. S. 30° 00' E. | sin. | =9.69897 |

| | | |
|---|---|---|
| Dist. | 428'.0 | 2.63144 |
| Co. S. 30° 00' E. | cos. | +9.93753 |
| Prop. dif. lat. | 370'.7 | =2.56897 |

| | | | |
|---|---|---|---|
| Lat. left | 20° 15' 00" N. | Mer. parts | 1233'.0 |
| Dif. 370'.7 = | — 6 10 42 S. | | |
| Lat. ship | 14 04 18 N. | Mer. parts | — 846.9 |
| | | Dif. | 386.1 S. |

| | | |
|---|---|---|
| Mer. dif. | 286'.1 | 2.58670 |
| Co. S. 30° 00' E. | tang. | +9.76144 |
| Dif. long. | 3° 42' 54" E. = 222'.9 | =2.34814 |

| | |
|---|---|
| Long. left | 74° 08' 01" W. |
| Dif. 222'.9 = | — 3 42 54 E. |
| Long. ship | 70 25 07 W. |

## EXPLANATION

From the logarithm of the departure 214′.0 E. subtract the logarithm of the distance 428′.0, which gives the logarithm sine of the course S. 30° E.

To the logarithm of the distance 428′.0 add the logarithm cosine of the course S. 30° E., which gives the logarithm of the proper difference of latitude 370′.7.

From the latitude left subtract the proper difference of latitude 370′.7 and the result will be the latitude of the ship.

From Table 3 take the meridional parts for both latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

To the logarithm of the meridional difference of latitude 386′.1 add the logarithm tangent of the course S. 30° E. and the result will be the logarithm of the difference of longitude 222′.9 E., which subtracted from the longitude left gives the longitude of the ship.

### EXAMPLE NUMBER 8

Both latitudes (one north and the other south) and both longitudes to find the course and distance: A ship is in latitude 4° 32′ 45″ N. and longitude 25° 35′ 45″ W. Find the course and distance to a point in latitude 1° 30′ 45″ S. and longitude 24° 05′ 15″ W. Find the course and distance.

| | | | |
|---|---|---|---|
| Lat. ship | 4° 32′ 45″ N. | Mer. parts | 271′.4 |
| Lat. point | + 1 30 45 S. | Mer. parts | + 90.4 |
| Dif. | 363′.5 = 6 03 30 S. | Dif. | 361.8 S. |

| | |
|---|---|
| Long. ship | 25° 35′ 45″ W. |
| Long. point | — 24 05 15 W. |
| Dif. | 90′.5 = 1 30 30 E. |

| | | |
|---|---|---|
| Dif. long. | 90′.5 | 1.95665 |
| Mer. dif. | 361.8 — | 2.55847 |
| Co. S. 14° 03′ E. | = tang. | 9.39818 |

| | | |
|---|---|---|
| Co. S. 14° 03′ E. | sec. | .01319 |
| Prop. dif. lat. | 363′.5 + | 2.56050 |
| Dist. | 374.7 = | 2.57369 |

## EXPLANATION

Find the difference of latitude by adding the latitude of the point to that of the ship, convert it into miles and name it south, because the point is south of the latitude of the ship.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference by adding, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Find the difference of longitude by subtracting the longitude of the point from that of the ship, convert it into miles and name it east, because the point is east of the longitude of the ship.

From the logarithm of the difference of longitude 90′.5 subtract the logarithm of the meridional difference of latitude 361′.8, which gives the logarithm tangent of the course S. 14° 03′ E.

To the logarithm secant of the course S. 14° 03′ E. add the logarithm of the proper difference of latitude 363′.5, which gives the logarithm of the distance 374′.7.

When the places under consideration lie so near the equator, it is not necessary to use Mercator sailing unless requested to do so at an examination, as plain sailing, in which the degrees of latitude and longitude are supposed to be equal, will give a result practically the same.

### EXAMPLE NUMBER 9

Find the course and distance from Sandy Hook light in latitude 40° 27′ 42″ N., and longitude 74° 00′ 09″ W. to Cape of Good Hope light in latitude 34° 21′ 12″ S., and 18° 29′ 26″ E.

| | | | |
|---|---|---|---|
| Lat. Sandy Hk. | 40° 27′ 42″ N. | Mer. parts | 2644′.2 |
| Lat. Cape G. H. + | 34 21 12 S. | Mer. parts | + 2183.7 |
| Dif. 4488′.9 = | 74 48 54 S. | Dif. | 4827.9 S. |

| | |
|---|---|
| Long. Sandy Hook | 74° 00′ 09″ W. |
| Long. Cape Good Hope + | 18 29 26 E. |
| Dif. 5549′.6 = | 92 29 35 E. |

| | | |
|---|---|---|
| Dif. long. | 5549′.6 | 3.74429 |
| Mer. dif. | 4827.9 — | 3.68377 |
| Co. S. 48° 59′ E. | = tang. | 0.06052 |

| | | |
|---|---|---|
| Co. S. 48° 59′ E. | sec. | .18291 |
| Prop. dif. lat. | 4488′.9 + | 3.65215 |
| Dist. | 6840.0 = | 3.83506 |

## EXPLANATION

Find the difference of latitude by adding the latitude of Cape of Good Hope to that of Sandy Hook, convert it into miles and name it south, because Cape of Good Hope is south of the latitude of Sandy Hook.

From Table 3 take the meridional parts for latitudes to the nearest mile and find their difference by adding, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Find the difference of longitude by adding the longitude of Cape of Good Hope to that of Sandy Hook, convert it into miles and name it east, because Cape of Good Hope is east of the longitude of Sandy Hook.

From the logarithm of the difference of longitude 5549′.6 subtract the logarithm of the meridional difference of latitude 4827′.9, which gives the logarithm tangent of the course S. 48° 59′ E.

To the logarithm secant of the course S. 48° 59′ E. add the logarithm of the proper difference of latitude 4488′.9 and the result will be the logarithm of the distance 6840′.0.

### EXAMPLE NUMBER 10

Find the course and distance from Cape Horn in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to Cape of Good Hope in latitude 34° 21′ 12″ S. and longitude 18° 29′ 26″ E.

| | | | | |
|---|---|---|---|---|
| Lat. Cape Horn | | 55° 58′ 41″ S. | Mer. parts | 4052.7 |
| Lat. Cape G. H. | | —34 21 12 S. | Mer. parts | —2183.7 |
| Dif. | 1297′.5 = | 21 37 29 N. | Dif. | 1869.0 N. |

| | | |
|---|---|---|
| Long. Cape Horn | | 67° 16′ 15″ W. |
| Long. Cape Good Hope | | + 18 29 26 E. |
| Dif. | 5145′.7 = | 85 45 41 E. |

| | | |
|---|---|---|
| Dif. long. | 5145′.7 | 3.71145 |
| Mer. dif. | 1869.0 — | 3.27161 |
| Co. N. 70° 02′ E. | = tang. | 0.43984 |
| Co. N. 70° 02′ E. | sec. | .46664 |
| Prop. dif. lat. | 1297′.5 + | 3.11311 |
| Dist. | 3799.7 = | 3.57975 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of Cape of Good Hope from that of Cape Horn, convert it into miles and name it north, because Cape of Good Hope is north of the latitude of Cape Horn.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

Find the difference of longitude by adding the longitude of Cape of Good Hope to that of Cape Horn, convert it into miles and name it east, because Cape of Good Hope is east of the longitude of Cape Horn.

From the logarithm of the difference of longitude 5145′.7 E. subtract the logarithm of the meridional difference of latitude 1869′.0 N., which gives the logarithm tangent of the course N. 70° 02′ E.

To the logarithm secant of the course N. 70° 02′ E. add the logarithm of the proper difference of latitude 1297′.5 and the result will be the logarithm of the distance 3799′.7.

### EXAMPLE NUMBER II

Find the course and distance from Cape Horn in latitude 55° 58′ 41″ S. and longitude 67° 16′ 15″ W. to Sydney, Australia, in latitude 33° 51′ 41″ S. and longitude 151° 12′ 23″ E.

| | | | | | |
|---|---|---|---|---|---|
| Lat. Cape Horn | | 55° 58′ 41″ | S. | Mer. parts | 4052′.7 |
| Lat. Sydney | | —33 51 41 | S. | Mer. parts | —2148.8 |
| Dif. | 1327′.0 = | 22 47 00 | N. | Dif. | 1903.9 N. |

| | | | |
|---|---|---|---|
| Long. Cape Horn | | 67° 16′ 15″ | W. |
| Long. Sydney | | + 151 12 23 | E. |
| Dif. | | —218 28 38 | E. |
| | | 360 00 00 | |
| Dif. | 8491′.4 = | 141 31 22 | W. |

| | | |
|---|---|---|
| Dif. long. | 8491′.4 | 3.92898 |
| Mer. dif. | 1903.9 — | 3.27965 |
| Co. N. 77″ 22′ W. | = tang. | 0.64933 |

| | | |
|---|---|---|
| Co. N. 77° 22′ W. | sec. | .66013 |
| Prop. dif. lat. | 1327′.0 + | 3.12287 |
| Dist. | 6067.4 = | 3.78300 |

## EXPLANATION

Find the difference of latitude by subtracting the latitude of Sydney from that of Cape Horn, convert it into miles and name it north, because Sydney is north of Cape Horn.

From Table 3 take the meridional parts for the latitudes to the nearest mile and find their difference, which is the meridional difference of latitude and takes the same name as the proper difference of latitude.

To the longitude of Cape Horn add the longitude of Sydney, because they are of different name and the result will be the difference of longitude east and as it is greater than 180° it is subtracted from 360° and gives the difference of longitude 8491′.4 W.

From the logarithm of the difference of longitude 8491′.4 subtract the logarithm of the meridional difference of latitude 1903′.9, which gives the logarithm tangent of the course N. 77° 22′ W.

To the logarithm secant of the course N. 77° 22′ W. add the logarithm of the proper difference of latitude 1327′.0 and the result will be the logarithm of the distance 6067′.4.

## DAY'S WORK

Example 1.—A ship had Cape Henry light bearing N. W. ½ W. distant 9 miles, ship's head S. ½ E. Deviations as per table on page 16. Throughout the 24 hours a current set N. N. E. magnetic 1⅛ miles per hour. Variation 6° W. The ship was sailed as follows:

| COURSE | WIND | LEEWAY | DISTANCE |
|---|---|---|---|
| S. by E. ½ E. | W. | ¼ pt. | 50′.4 |
| S. by E. ¾ E. | W. S. W. | 0 | 47.3 |
| S. E. by E. | S. | ¾ pt. | 9.8 |
| S. W. | S. S. E. | ½ pt. | 20.3 |
| W. N. W. | S. S. E. | 0 | 10.7 |
| S. W. | S. S. E. | ¾ pt. | 12.4 |

Find the course and distance made good and the ship's position. From that point find the course and distance to Diamond Shoal lightship.

| CAPE HENRY | | DIAMOND SHOAL | |
|---|---|---|---|
| Lat. | 36° 55′ 35″ N. | Lat. | 35° 05′ 08″ N. |
| Long. | 76 00 27 W. | Long. | 75 19 38 W. |

| Compass Courses. | Wind. | Leeway | Var. | Dev. | Dist. | True Courses. | Dif Lat. | | Dep. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | N. | S. | E. | W. |
| S. E. ½ E. | | | 6° W. | 1°30′W | 9′.0 | S. 58°07′E. | | 4′.8 | 7′.6 | |
| S. by E. ½ E. | W. | ¼ pt. | 6 W | 10 00 W. | 50.4 | S. 35 41 E. | | 41.0 | 29.3 | |
| S. by E. ¾ E | W. S. W. | 0 pt. | 6 W. | 14 00 W. | 47.3 | S. 39 41 E. | | 36.5 | 30.1 | |
| S. E. by E. | S. | ¾ pt. | 6 W. | 24 00 W. | 9.8 | N. 85 19 E | .8 | | 9.8 | |
| S. W. | S. S. E. | ½ pt. | 6 W. | 26 00 E. | 20.3 | S. 70 37 W. | | 6.8 | | 19.0 |
| W. N. W. | S. S. E. | 0 pt. | 6 W. | 14 00 E. | 10.7 | N. 59 30 W. | 5.4 | | | 9.2 |
| S. W. | S. S. E. | ¾ pt. | 6 W. | 26 00 E. | 12.4 | S. 73 26 W. | | 3.5 | | 11.9 |
| N. N. E. | | | 6 W. | | 27.0 | N. 16 30 E. | 25.9 | | 7.7 | |
| | | | | | | | 32.1 | 92.6 | 84.5 | 40.1 |
| | | | | | | | | 32.1 | 40.1 | |
| | | | | | | | | 60.5 | 44.4 | |

MERCATOR SAILING BY INSPECTION

| | | | | |
|---|---|---|---|---|
| Lat. Cape Hen. | 36° 55′ 35″ | N. | Mer. parts | 2373′.6 |
| Dif. 60′.5 = — | 1 00 30 | S. | | |
| Lat. ship | 35 55 05 | N. | Mer. parts | — 2298.1 |
| | | | Dif. | 75.5 S. |

$$\left.\begin{array}{ll}\text{Prop. dif. lat.} & 60'.5\ \text{S.}\\ \text{Dep.} & 44.4\ \text{E.}\end{array}\right\} = \text{Co. S. } 36^\circ \text{ E.}$$

$$\left.\begin{array}{ll}\text{Co. S. } 36^\circ \text{ E.} & \\ \text{Mer. dif.} & 75'.5\end{array}\right\} = \text{Dif. long. } 54'.7 \text{ E.}$$

| | | |
|---|---|---|
| Long. Cape Hen. | 76° 00′ 27″ | W. |
| Dif. 54′.7 E. = — | 54 42 | E. |
| Long. ship | 75 05 45 | W. |

$$\left.\begin{array}{ll}\text{Co. S. } 36^\circ \text{ E.} & \\ \text{Prop. dif. lat.} & 60'.5\end{array}\right\} = \text{dist. } 75'.0$$

### MIDDLE LATITUDE SAILING BY INSPECTION

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lat. ship | | 35° 55′ 05″ | N. | Long. ship | | —75° 05′ 45″ | W. |
| Lat. Dia. S. | — | 35 05 08 | N. | Long. Dia. S. | | 75 19 38 | W. |
| Dif. | 49′.95 = | 49 57 | S. | Dif. | 13′.9 = | 13 53 | W. |

| | | | |
|---|---|---|---|
| Lat. ship | | 35 55 05 | N. |
| Lat. Dia. S. | + | 35 05 08 | N. |
| | 2) | 71 00 13 | |
| Middle lat. | | 35 30 06 | = 35° ½ dif. long. 13′.9 dep. 11′.3 |

$$\left.\begin{array}{lll}\text{Dif. lat.} & 49'.95 & \text{S.}\\ \text{Dep.} & 11.3 & \text{W.}\end{array}\right\} = \text{Co. S. } 13^\circ \text{ W. dist. } 51'.2$$

### ALL BY MIDDLE LATITUDE SAILING BY LOGARITHMS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lat. Cape Hen. | | 36° 55′ 35″ | N. | Long. Cape Hen. | | 76° 00′ 27″ | W. |
| Dif. | 60′.5 — | 1 00 30 | S. | Dif. | — | 55 11 | E. |
| Lat. ship | | 35 55 05 | N. | Long. ship | | 75 05 16 | W. |

| | | | |
|---|---|---|---|
| Lat. Cape Hen. | | 36° 55′ 35″ | N. |
| Lat. ship | + | 35 55 05 | N. |
| | 2) | 72 50 40 | |
| Middle lat. | | 36 25 20 | |

| | | |
|---|---|---|
| Dep. | 44′.4 | 1.64738 |
| Mid. lat. 36° 25′ 20″ | cos. — | .90562 |
| Dif. long. | 55′ 11″ = 55′.18 = | 0.74176 |

| | | |
|---|---|---|
| Dep. | 44′.4 | 1.64738 |
| Dif. lat. | 60.5 — | 1.78176 |
| Co. S. 36° 16′ E. | = tang. | 9.86562 |

| | | |
|---|---|---|
| Dep. | 44′.4 | 1.64738 |
| Co. S. 36° 16′ E. | sin. — | 9.77199 |
| Dist. | 75′.06 = | 1.87539 |

| | | | | | |
|---|---|---|---|---|---|
| Lat. ship | | 35° 55′ 05″ N. | Long. ship | | −75° 05′ 16″ W. |
| Lat. Dia. S. | | −35 05 08 N. | Long. Dia. S. | | 75 19 38 W. |
| Dif. | 49′.95 = | 49 57 S. | Dif. | 14′.37 = | 14 22 W. |

| | | |
|---|---|---|
| Lat. ship | | 35° 55′ 05″ N. |
| Lat. Dia. S. | | + 35 05 08 N. |
| | 2) | 71 00 13 |
| Middle lat. | | 35 30 06 |

| | | |
|---|---|---|
| Dif. long. | 14′.37 | 1.15746 |
| Middle lat. 35° 30′ 06″ | cos. | + 9.91068 |
| Dep. | 11′.7 | = 1.06814 |
| Dif. lat. | 49.95 | − 1.69854 |
| Co. S. 13° 11′ W. | = tang. | = 9.36960 |

| | | |
|---|---|---|
| Co. S. 13° 11′ W. | sec. | .01160 |
| Dif. lat. | 49′.95 | + 1.69854 |
| Dist. | 51.3 | = 1.71014 |

## PRACTICAL DEAD RECKONING

The traverse table is not used in the practice of navigation, but its use must be learned that more practical means may be used to keep account of a ship's track.

Usually the following method is not wanted at an examination, but should be used in practice. The former is quite satisfactory so far as the final result is concerned, which is not known until the end of the day. By this the ship's position may be known at any moment. In other words, by one the ship takes the man and by the other the man takes the ship.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lat. Cape H. | | 36° 55′.6 N. | | | Long. Cape H. | | 76° 00′.4 W. |
| Dif. | − | 4 .8 S. | = 37° dep. | 7′.6 = | dif. | − | 9 .5 E. |
| Lat. noon | | 36 50 .8 N. | | | Long. noon | | 75 50 .9 W. |
| Dif. | − | 41 .0 S. | = 36 dep. | 29 .3 = | dif. | − | 36 .2 E. |
| Lat. 4 P.M. | | 36 09 .8 N. | | | Long. 4 P.M. | | 75 14 .7 W. |
| Dif. | − | 36 .5 S. | = 36 dep. | 30 .1 = | dif. | − | 37 .2 E. |
| Lat. 8 P.M. | | 35 33 .3 N. | | | Long. 8 P.M. | | 74 37 .5 W. |
| Dif. | + | .8 N. | = 36 dep. | 9 .8 = | dif. | − | 12 .1 E. |
| Lat. Mdt. | | 35 34 .1 N. | | | Long. Mdt. | | 74 25 .4 W. |
| Dif. | − | 6 .8 S. | = 36 dep. | 19 .0 = | dif. | + | 23 .5 W. |
| Lat. 4 A.M. | | 35 27 .3 N. | | | Long. 4 A.M. | | 74 48 .9 W. |
| Dif. | + | 5 .4 N. | = 36 dep. | 9 .2 = | dif. | + | 11 .4 W. |
| Lat. 8 A.M. | | 35 32 .7 N. | | | Long. 8 A.M. | | 75 00 .3 W. |
| Dif. | − | 3 .5 S. | = 36 dep. | 11 .9 = | dif. | + | 14 .7 W. |
| Lat. noon | | 35 29 .2 N. | | | Long. noon | | 75 15 .0 W. |
| Dif. (current) | + | 25 .9 N. | = 36 dep. | 7 .7 = | dif. (current) | − | 9 .5 E. |
| Lat. noon | | 35 55 .1 N. | | | Long. noon | | 75 05 .5 W. |

The result is two noon positions, the first without considering the current which in the other is taken into account.

The current could be considered on each course, but such a degree of precision is seldom necessary.

The ship's position differs slightly from that found by the preceding method; but is quite near enough to meet the demands of practice.

| | | | |
|---|---|---|---|
| Lat. Cape H. | 36° 55′.6 N. | Long. Cape H. | 76° 00′.4 W. |
| Lat. ship | − 35 55 .1 N. | Long. ship | − 75 05 .5 W. |
| Dif. | 60′.5 = 1 00 .5 S. | Dif. | 54 .9 E. |

Mid. lat. 36° dif. long. 54′.9 = dep. 44′.4

$$\left.\begin{array}{ll}\text{Dif. lat.} & 60^\circ.5\ \text{S.}\\ \text{Dep.} & 44\ .4\ \text{E.}\end{array}\right\} = \text{Co. S. } 36^\circ\ \text{E. dist. } 75'.0$$

| | | | |
|---|---|---|---|
| Lat. ship | 35° 55′.1 N. | Long. ship | − 75° 05′.5 W. |
| Lat. Dia. S. | − 35 05 .1 N. | Long. Dia. S. | 75 19 .6 W. |
| Dif. | 50 .0 S. | Dif. | 14 .1 W. |

Mid. lat. 35°½ dif. long. 14′.1 = dep. 11′.5

$$\left.\begin{array}{ll}\text{Dif. lat} & 50'.0\ \text{S.}\\ \text{Dep.} & 11\ .5\ \text{W.}\end{array}\right\} = \text{Co. S. } 13^\circ\ \text{W. dist. } 51'.3$$

The distance being small, middle latitude sailing is used in the last part of this example.

## DAY'S WORK

Example 2.—A ship had Fire Island light bearing N. N. E. distant 10-5/10 miles, ship's head S. ½ W. Variation 10° 00′ W. Deviations as per table on page 16. Throughout the 24 hours a current set N. E. magnetic and its drift 7/8 mile per hour. The ship was sailed as follows:

| COURSE | WIND | LEEWAY. | DISTANCE |
|---|---|---|---|
| E. by S. ½ S. | S. by E. | ½ pt. | 40′.2 |
| S. by W. ½ W. | S. E. | ½ pt. | 36 .7 |
| S. E. ½ S. | S. S. W. | ½ pt. | 38 .5 |
| S. ½ W. | W. S. W. | ½ pt. | 39 .4 |
| S. S. E. | W. | ¼ pt. | 56 .3 |
| S. E. by S. | W. N. W. | | 63 .6 |

Find the course and distance made good and the ship's position. From that point find the course and distance to Cape Henry light.

| FIRE ISLAND LIGHT | CAPE HENRY LIGHT |
|---|---|
| Lat. 40° 37′ 57″ N. | Lat. 36° 55′ 35″ N. |
| Long. 73° 13′ 08″ W. | Long. 76° 00′ 27″ W. |

| Compass Courses. | Wind. | Lee-way. | Var. | Dev. | Dist. | True Courses | Dif. Lat. | | Dep. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | N. | S. | E. | W. |
| S. S. W. | | | 10° W. | 7° 30′ E. | 10.′5 | S. 20°00′W. | | 9′.9 | | 3′.6 |
| E. bv S. ½ S. | S. by E. | ½ pt. | 10 W. | 23 30 W. | 40. 2 | N. 67 45 E. | 15′.1 | | 37′.3 | |
| S. by W. ½ W. | S. E. | ½ pt. | 10 W. | 15 00 E. | 36. 7 | S. 27 30 W. | | 32.5 | | 16.9 |
| S. E. ½ S. | S. S. W. | ½ pt. | 10 W. | 21 45 W. | 38. 5 | S. 76 45 E. | | 8.7 | 37.5 | |
| S. ½ W. | W. S. W. | ½ pt. | 10 W. | 7 30 E. | 39. 4 | S. 2 30 E. | | 39.4 | 1.7 | |
| S. S. E. | W. | ¼ pt. | 10 W. | 14 00 W. | 56. 3 | S. 49 19 E. | | 36.6 | 42.5 | |
| S. E. by S. | W. N. W. | | 10 W. | 20 00 W. | 63. 6 | S. 63 45 E. | | 27.9 | 57.2 | |
| N. E. | | | 10 W. | | 21. 0 | N. 35 00 E. | 17.2 | | 12.0 | |
| | | | | | | | 32.3 | 155.0 | 188.5 | 20.5 |
| | | | | | | | | 32.3 | 20.5 | |
| | | | | | | | | 122.7 | 168.0 | |

### MIDDLE LATITUDE SAILING BY INSPECTION

$$\left.\begin{array}{ll}\text{Dif. lat.} & 122'.7\text{ S.}\\ \text{Dep.} & 168.0\text{ E.}\end{array}\right\} = \text{Co. S. } 54^\circ\text{ E. dist. } 208'.0$$

| | | | | | |
|---|---|---|---|---|---|
| Lat. Fire I. L. | 40° 37′ 57″ | N. | Long. Fire I. L. | 73° 13′ 08″ | W. |
| Dif. 122′.7 = — | 2 02 42 | S. | Dif. 217′.5 = — | 3 37 30 | E. |
| Lat. ship | 38 35 15 | N. | Long. ship | 69 35 38 | W. |

| | | |
|---|---|---|
| Lat. Fire I. L. | 40° 37′ 57″ | N. |
| Lat. ship | + 38 35 15 | N. |
| | 2)79 13 12 | |
| Middle lat. | = 39 36 36 | |

Middle lat. 39°½ dep. 168′.0 = dif. long. 217′.5 = 3° 37′ 30″ E.

### MERCATOR SAILING BY INSPECTION

| | | | | |
|---|---|---|---|---|
| Lat. ship | 38° 35′ 15″ | N. | Mer. parts | 2498′.3 |
| Lat. Cape H. | — 36 55 35 | N. | Mer. parts | —2373.6 |
| Dif. 99′.7 = | 1 39 40 | S. | Dif. | 124.7 S. |

| | | |
|---|---|---|
| Long. ship | — 69° 35′ 38″ | W. |
| Long. Cape Henry | 76 00 27 | W. |
| Dif. 384′.8 = | 6 24 49 | W. |

$$\left.\begin{array}{ll}\text{Mer. dif. lat.} & 124'.7\text{ S.}\\ \text{Dif. long.} & 384.8\text{ W.}\end{array}\right\} = \text{Co. S. } 72^\circ\text{ W.}$$

$$\left.\begin{array}{l}\text{Co. S. } 72^\circ\text{ W.}\\ \text{Prop. dif. lat. } 99'.7\end{array}\right\} = \text{Distance } 323'.0$$

### ALL MERCATOR SAILING BY LOGARITHMS

| | | |
|---|---|---|
| Dep. | 168′.0 E. | 2.22531 |
| Prop. dif. lat. | 122 .7 S. | —2.08884 |
| Co. S. 53° 51′ E. | = tang. | 0.13647 |

| | | |
|---|---|---|
| Prop. dif. lat. | 122′.7 | 2.08884 |
| Co. S. 53° 51′ E. | sec. | + .22922 |
| Dist. | 208′.0 | = 2.31806 |

| | | | |
|---|---|---|---|
| Lat. Fire I. L. | 40° 37′ 57″ N. | Mer. parts | 2657′.3 |
| Dif. 122′.7 = — | 2 02 42 S. | | |
| Lat. ship | 38 35 15 N. | Mer. parts | — 2498 .3 |
| | | | 159 .0 S. |

| | | |
|---|---|---|
| Mer. dif. | 159′.0 | 2.20140 |
| Co. S. 53° 51′ E. | tang. | + .13647 |
| Dif. long. | 217′.7 | = 2.33787 |

| | |
|---|---|
| Long. Fire I. L. | 73° 13′ 08″ W. |
| Dif. 217′.7 = — | 3 37 42 E. |
| Long. ship | 69 35 26 W. |

| | | | |
|---|---|---|---|
| Lat. ship | 38° 35′ 15″ N. | Mer. parts | 2498′.3 |
| Lat. Cape H. | —36 55 35 N. | Mer. parts | — 2373 .6 |
| Dif. 99′.7 = | 1 39 40 S. | Dif. | 124 .7 S. |

| | |
|---|---|
| Long. ship | — 69° 35′ 26″ W. |
| Long. Cape H. | 76 00 27 W. |
| Dif. 385′.0 = | 6 25 01 W. |

| | | |
|---|---|---|
| Dif. long. | 385′.0 | 2.58546 |
| Mer. dif. | 124 .7 | —2.09587 |
| Co. S. 72° 03′ W. | = tang. | 0.48959 |

| | | |
|---|---|---|
| Co. S. 72° 03′ W. | sec. | .51119 |
| Prop. dif. lat. | 99′.7 | + 1.99870 |
| Dist. | 323 .5 | = 2.50989 |

## PRACTICAL DEAD RECKONING

The traverse table is not used in the practice of navigation, but its use must be learned that more practical means may be used to keep account of a ship's track.

Usually the following method is not wanted at an examination, but should be used in practice. The former is quite satisfactory so far as the final result is concerned, which is not known until the end of the day. By this the ship's position may be known at any moment. In other words, by one the ship takes the man and by the other the man takes the ship.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lat. Fire I. | | 40° 38′.0 N. | | | Long. Fire I. | | 73° 13′.1 W. |
| Dif. | − | 9.9 S. | = 40° dep. | 3′.6 = | dif. | + | 4.7 W. |
| Lat. noon | | 40 28.1 N. | | | Long. noon | | 73 17.8 W. |
| Dif. | + | 15.1 N. | = 41 dep. | 37.3 = | dif. | − | 49.4 E. |
| Lat. 4 P.M. | | 40 43.2 N. | | | Long. 4 P.M. | | 72 28.4 W. |
| Dif. | − | 32.5 S. | = 40 dep. | 16.7 = | dif. | + | 21.8 W. |
| Lat. 8 P.M. | | 40 10.7 N. | | | Long. 8 P.M. | | 72 50.2 W. |
| Dif. | − | 8.7 S. | = 40 dep. | 37.5 = | dif. | − | 49.0 E. |
| Lat. Mdt. | | 40 02.0 N. | | | Long. Mdt. | | 72 01.2 W. |
| Dif. | − | 39.4 S. | = 40 dep. | 1.7 = | dif. | − | 2.2 E. |
| Lat. 4 A.M. | | 39 22.6 N. | | | Long. 4 A.M. | | 71 59.0 W. |
| Dif. | − | 36.9 S. | = 39 dep. | 42.8 = | dif. | − | 55.8 E. |
| Lat. 8 A.M. | | 38 45.7 N. | | | Long. 8 A.M. | | 71 03.9 W. |
| Dif. | − | 27.9 S. | = 39 dep. | 57.2 = | dif. | − | 1 13.6 E. |
| Lat. noon | | 38 17.8 N. | | | Long. noon | | 69 50.3 W. |
| Dif. (current) | + | 17.2 N. | = 38 dep. | 12.0 = | dif. (current) | − | 15.2 E. |
| Lat. noon | | 38 35.0 N. | | | Long. noon | | 69 35.1 W. |

## PRACTICAL DEAD RECKONING

The traverse table is not used in the practice of navigation, but its use must be learned that more practical means may be used to keep account of a ship's track.

Usually the following method is not wanted at an examination, but should be used in practice. The former is quite satisfactory so far as the final result is concerned, which is not known until the end of the day. By this the ship's position may be known at any moment. In other words, by one the ship takes the man and by the other the man takes the ship.

| | | | | | | |
|---|---|---|---|---|---|---|
| Lat. Fire I. | | 40° 38′.0 N. | | Long. Fire I. | | 73° 13′.1 W. |
| Dif. | − | 9.9 S. | = 40° dep. 3′.6 = | dif. | + | 4.7 W. |
| Lat. noon | | 40 28.1 N. | | Long. noon | | 73 17.8 W. |
| Dif. | + | 15.1 N. | = 41 dep. 37.3 = | dif. | − | 49.4 E. |
| Lat. 4 P.M. | | 40 43.2 N. | | Long. 4 P.M. | | 72 28.4 W. |
| Dif. | − | 32.5 S. | = 40 dep. 16.7 = | dif. | + | 21.8 W. |
| Lat. 8 P.M. | | 40 10.7 N. | | Long. 8 P.M. | | 72 50.2 W. |
| Dif. | − | 8.7 S. | = 40 dep. 37.5 = | dif. | − | 49.0 E. |
| Lat. Mdt. | | 40 02.0 N. | | Long. Mdt. | | 72 01.2 W. |
| Dif. | − | 39.4 S. | = 40 dep. 1.7 = | dif. | − | 2.2 E. |
| Lat. 4 A.M. | | 39 22.6 N. | | Long. 4 A.M. | | 71 59.0 W. |
| Dif. | − | 36.9 S. | = 39 dep. 42.8 = | dif. | − | 55.8 E. |
| Lat. 8 A.M. | | 38 45.7 N. | | Long. 8 A.M. | | 71 03.9 W. |
| Dif. | − | 27.9 S. | = 39 dep. 57.2 = | dif. | − | 1 13.6 E. |
| Lat. noon | | 38 17.8 N. | | Long. noon | | 69 50.3 W. |
| Dif. (current) | + | 17.2 N. | = 38 dep. 12.0 = | dif. (current) | − | 15.2 E. |
| Lat. noon | | 38 35.0 N. | | Long. noon | | 69 35.1 W. |

The result is two noon positions, the first without considering the current, which in the other is taken into account.

The current could be considered on each course, but such a degree of precision is seldom necessary.

The ship's position differs slightly from that found by the preceding method, but is quite near enough to meet the demands of practice.

| | | | | |
|---|---|---|---|---|
| Lat. Fire I. | 40° 38'.0 N. | Long. Fire I. | | 73° 13'.1 W. |
| Lat. ship | − 38 35.0 N. | Long. ship | | — 69 35.1 W. |
| Dif. 123'.0 = | 2 03.0 S. | Dif. | 218'.0 = | 3 38.0 E |

Mid. lat. 39°½ dif. long. 218'.0 = dep. 168'.2

$$\left.\begin{array}{ll}\text{Dif. lat.} & 123'.0\ \text{S.}\\ \text{Dep.} & 168.2\ \text{E.}\end{array}\right\} = \text{Co. S. } 54^\circ \text{ E. dist. } 208'.0$$

| | | | |
|---|---|---|---|
| Lat. ship | 38° 35'.0 N. | Mer. parts | 2498'.3 |
| Lat. Cape H. | — 36 55.6 N. | Mer. parts | — 2373.6 |
| Dif. 99'.4 = | 1 39.4 S. | Dif. | 124.7 S. |

| | |
|---|---|
| Long. ship | — 69° 35'.1 W. |
| Long. Cape H. | 76 00.4 W. |
| Dif. 385'.3 = | 6 25.3 W. |

$$\left.\begin{array}{ll}\text{Mer. dif. lat.} & 124'.7\ \text{S.}\\ \text{Dif. long.} & 385.3\ \text{W.}\end{array}\right\} = \text{Co. S. } 72^\circ \text{ W.}$$

Prop. dif. lat. 99'.4 = dist. 322'.0

The course and distance in the last part of this problem may be found by either Mercator or middle latitude sailing, by inspection, but the former would be preferable, as the course is more than 45° and by doing so save the trouble of close interpolation to convert the difference of longitude into departure.

## DAY'S WORK

Example 3.—Farralon light bore E. by N. distant 9.7 miles. Ship's head N. W. by W. Deviations as per table on page 16. Throughout the day a current set S. E. (magnetic) ⅞ of a mile per hour. Variation 19° 30′ E. The ship was then sailed as follows:

| COURSE | WIND | LEEWAY | DISTANCE |
|---|---|---|---|
| N. W. by W. | N. by E. | ¼ pt. | 45′.3 |
| W. by N. | N. N. W. | ¼ pt. | 50.2 |
| W. | N. W. by N. | ½ pt. | 39.6 |
| N. | E. N. E. | ¼ pt. | 51.4 |
| N. W. ½ W. | N. by E. | ½ pt. | 34.7 |
| N. by W. ½ W. | N. E. | ¼ pt. | 21.0 |

Find the course and distance made good and the ship's position. From that point find the course and distance to Cape Flattery light.

| | FARRALON LIGHT | | CAPE FLATTERY LIGHT |
|---|---|---|---|
| Lat. | 37° 41′ 51″ N. | Lat. | 48° 23′ 30″ N. |
| Long. | 123° 00′ 07″ W. | Long. | 124° 44′ 06″ W. |

| Compass Courses. | Wind. | Lee-way. | Var. | Dev. | Dist. | Truc Courses. | DIF. LAT. |  | DEP. |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | N. | S. | E. | W. |
| W. by S. |  |  | 19°30′E. | 9°00′ E. | 9′.7 | N.72°45′ W. | 2′.8 |  |  | 9′.3 |
| N. W by W. | N. by E. | ¼ pt. | 19 30 E | 9 00 E. | 45.3 | N.30 34 W. | 39.0 |  |  | 23.0 |
| W. by N. | N. N. W. | ¼ pt. | 19 30 E. | 17 00 E. | 50.2 | N.45 04 W. | 35.5 |  |  | 35.5 |
| W. | N.W.by N. | ½ pt. | 19 30 E. | 20 00 E. | 39.6 | N.56 08 W. | 22.1 |  |  | 32.8 |
| N | E. N. E. | ¼ pt. | 19 30 E. | 7 00 W. | 5 .4 | N. 9 41 E. | 50.7 |  | 8′.5 |  |
| N. W. ½ W. | N. by E. | ½ pt. | 19 30 F. | 7 30 E. | 34.7 | N.29 15 W. | 30.3 |  |  | 16.8 |
| N.by W.½W. | N. E. | ¼ pt. | 19 30 E. | 1 30 W. | 21.0 | N. 1 41 W. | 21.0 |  |  | .5 |
| S. E. |  |  | 19 30 E. |  | 21.0 | S. 25 30 E. | 21.0 | 18.′9 | 9.0 |  |
|  |  |  |  |  |  |  | 201.4<br>18.9 | 18. 9 | 17.5 | 117.9<br>17.5 |
|  |  |  |  |  |  |  | 182.5 |  |  | 100.4 |

MIDDLE LATITUDE SAILING BY INSPECTION

$$\left.\begin{array}{ll}\text{Dif. lat.} & 182'.5\ \text{N.}\\ \text{Dep.} & 100.4\ \text{W.}\end{array}\right\} = \text{Co. N. } 29^\circ \text{ W. dist. } 209'.0$$

$$\begin{array}{lrl}\text{Lat. F. L.} & 37^\circ\ 41'\ 51'' & \text{N.}\\ \text{Dif.}\quad 182'.5 = + & \underline{3\ \ 02\ \ 30} & \text{N.}\\ \text{Lat. ship} & 40\ \ 44\ \ 21 & \text{N.}\end{array}\qquad\begin{array}{lrl}\text{Long. F. L.} & 123^\circ\ 00'\ 07'' & \text{W.}\\ \text{Dif.}\quad 129'.0 = + & \underline{2\ \ 09\ \ 00} & \text{W.}\\ \text{Long. ship} & 125\ \ 09\ \ 07 & \text{W.}\end{array}$$

$$\begin{array}{lrl}\text{Lat. F. L.} & 37^\circ\ 41'\ 51'' & \text{N.}\\ \text{Lat. ship} & +\underline{40\ \ 44\ \ 21} & \text{N.}\\ & 2)\underline{78\ \ 26\ \ 12} & \\ \text{Middle lat.} & 39\ \ 13\ \ 06 & \end{array}$$

Middle lat. 39° dep. 100′.4 = dif. long. 129′.0 = 2° 09′ 00″ W.

### MERCATOR SAILING BY LOGARITHMS

| | | | |
|---|---|---|---|
| Lat. ship | —40° 44′ 21″ N. | Mer. parts | —2665.2 |
| Lat. Cape F. | 48 23 30 N. | Mer. parts | 3308.5 |
| Dif. 459′.2= | 7 39 09 N. | Dif. | = 643.3 N. |

| | |
|---|---|
| Long. ship | 125° 09′ 07″ W. |
| Long. Cape F. | —124 44 06 W. |
| Dif. 25′.0= | 25 01 E. |

| | | |
|---|---|---|
| Dif. long. | 25′.0 | 1.39794 |
| Mer. dif. | 643.3 — | 2.80841 |
| Co. N. 2° 14′ E. | =tang. | 8.58953 |

| | | |
|---|---|---|
| Co. N. 2° 14′ E. | sec. | .00033 |
| Prop. dif. lat. | 459′.2 + | 2.66200 |
| Dist. | 459.5 = | 2.66233 |

## PRACTICAL DEAD RECKONING

The traverse table is not used in the practice of navigation, but its use must be learned that more practical means may be used to keep account of a ship's track.

Usually the following method is not wanted at an examination, but should be used in practice. The former is quite satisfactory so far as the final result is concerned, which is not known until the end of the day. By this the ship's position may be known at any moment. In other words, by one the ship takes the man and by the other the man takes the ship.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lat. Far. L. | | 37° 41′.8 N. | | | Long. Far. L. | | 123° 00′.1 W. |
| Dif. | + | 2 .8 N. | = 38° dep. | 9′.3 = | dif. | + | 11 .8 W. |
| Lat. noon | | 37 44 .6 N. | | | Long. noon | | 123 11 .9 W. |
| Dif. | + | 39 .0 N. | = 38 dep. | 23 .0 = | dif. | + | 29 .2 W. |
| Lat. 4 P.M. | | 38 23 .6 N. | | | Long. 4 P.M. | | 123 41 .1 W. |
| Dif. | + | 35 .5 N. | = 39 dep. | 35 .5 = | dif. | + | 45 .7 W. |
| Lat. 8 P.M. | | 38 59 .1 N. | | | Long. 8 P.M. | | 124 26 .8 W. |
| Dif. | + | 22 .1 N. | = 39 dep. | 32 .8 = | dif. | + | 42 .2 W. |
| Lat. Mdt. | | 39 21 .2 N. | | | Long. Mdt. | | 125 09 0 W. |
| Dif. | + | 50 .7 N. | = 40 dep. | 8 .5 = | dif. | — | 11 .1 E. |
| Lat. 4 A.M. | | 40 11 .9 N. | | | Long. 4 A.M. | | 124 57 .9 W. |
| Dif. | + | 30 .3 N. | = 40 dep. | 16 .8 = | dif. | + | 21 .9 W. |
| Lat. 8 A.M. | | 40 42 .2 N. | | | Long. 8 A.M. | | 125 19 .8 W. |
| Dif. | + | 21 .0 N. | = 41 dep. | .5 = | dif. | + | .7 W. |
| Lat. noon | | 41 03 .2 N. | | | Long. noon | | 125 20 .5 W. |
| Dif. (current) | — | 18 .9 S. | = 41 dep. | 9 .0 = | dif. (current) | — | 11 .9 E. |
| Lat. noon | | 40 44 .3 N. | | | Long. noon | | 125 08 .6 W. |

The result is two noon positions, the first without considering the current, which in the other is taken into account.

The current could be considered on each course, but such a degree of precision is seldom necessary.

The ship's position differs slightly from that found by the preceding method, but is quite near enough to meet the demands of practice.

| | | | | | |
|---|---|---|---|---|---|
| Lat. Far. L. | | —37° 41'.8 N. | Long. Far. L. | | —123° 00'.1 W. |
| Lat. ship | | 40 44.3 N. | Long. ship | | 125 08.6 W. |
| Dif. | 182'.5 = | 3 02.5 N. | Dif. | 128'.5 = | 2 08.5 W. |

Mid. lat. 39° dif. long. 128'.5 = dep. 99'.9

$$\left.\begin{array}{ll}\text{Dif. lat.} & 182'.5\text{ N.}\\ \text{Dep.} & 99.9\text{ W.}\end{array}\right\} = \text{Co. N. } 29^\circ\text{ W. dist. } 209'$$

| | | | | |
|---|---|---|---|---|
| Lat. ship | | —40° 44'.3 N. | Mer. parts | —2665'.2 |
| Lat. Cape F. | | 48 23.5 N. | Mer. parts | 3308.5 |
| Dif. | 459'.2 = | 7 39.2 N. | Dif. | 643.3 N. |

| | | |
|---|---|---|
| Long. ship | | 125° 08'.6 W. |
| Long. Cape F. | | —124 44.1 W. |
| Dif. | 24'.5 = | 24.5 E. |

| | | |
|---|---|---|
| Dif. long. | 24'.5 | 1.38917 |
| Mer. dif. lat. | 643.3 — | 2.80841 |
| Co. N. 2° 11' E. | = tang. | 8.58076 |
| Co. N. 2° 11' E. | sec. | .00032 |
| Prop. dif. lat. | 459'.2 + | 2.66200 |
| Dist. | 459.5 = | 2.66232 |

The last course and distance has been found by Mercator sailing, using logarithms; but while by middle latitude sailing a result nearly the same is obtained, the former method should be favored when the distance is great or near the limits of Table 2.

## DAY'S WORK

Example 4.—A ship had Progreso light bearing S. by E. distant 6′.5. Ship's head S. by E. ½ E. Deviation as per table on page 16. Throughout the 24 hours a current set W. by S. (magnetic) ⅞ of a mile per hour. Variation 6° 45′ E. The ship was sailed as follows:

| COURSE | WIND | LEEWAY | DISTANCE |
|---|---|---|---|
| N. by E. ½ E. | N. W. | ½ pt. | 27′.4 |
| N. E. ½ N. | N. by W. | ½ pt. | 32.6 |
| N. W. ½ N. | N. by E. | ½ pt. | 33.4 |
| N. N. W. | N. E. | ¼ pt. | 46.7 |
| N. W. | N. E. | | 52.6 |
| N. N. W. | N. E. | ¼ pt. | 56.4 |

Find the course and distance made good and the ship's position. From that position find the course and distance to Heald Bank lightship.

| | PROGRESO LIGHT | | HEALD BANK LIGHTSHIP |
|---|---|---|---|
| Lat. | 21° 17′ 00″ N. | Lat. | 29° 06′ 05″ N. |
| Long. | 89° 39′ 30″ W. | Long. | 94° 12′ 27″ W. |

| Compass Courses. | Wind. | Lee-way | Var. | Dev. | Dist. | True Courses. | Dif. Lat. |  | Dep. |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | N. | S. | E. | W. |
| N. by W. |  |  | 6°45′ E. | 10°00′ W. | 6′.5 | N.14°30′W. | 6.′3 |  |  | 1′.6 |
| N. by E.½E. | N. W. | ½ pt. | 6 45 E. | 8 15 W, | 27.4 | N 21 00 E. | 25.6 |  | 9′.8 |  |
| N. E. ½ N. | N. by W. | ½ pt. | 6 45 E | 11 00 W. | 32.6 | N.40 45 E. | 24.6 |  | 21.4 |  |
| N. W. ½ N. | N. by E. | ½ pt. | 6 45 E, | 4 30 E. | 33.4 | N.33 45 W. | 27.7 |  |  | 15.7 |
| N. N. W. | N. E. | ¼ pt. | 6 45 E, | 0 | 46.7 | N.18 34 W. | 44.3 |  |  | 14.8 |
| N. W. | N. E. |  | 6 45 E. | 6 00 E. | 52.6 | N.32 15 W. | 44.6 |  |  | 27.9 |
| N. N. W. | N. E. | ¼ pt. | 6 45 E. | 0 | 56.4 | N.18 34 W. | 53.5 |  |  | 17.9 |
| W. by S. |  |  | 6 45 E. |  | 21.0 | S.85 30 W. |  | 1′ 6 |  | 20.9 |
|  |  |  |  |  |  |  | 226.6<br>1.6 | 1.6 | 31.2 | 101.8<br>31.2 |
|  |  |  |  |  |  |  | 225.0 |  |  | 70.6 |

## MIDDLE LATITUDE SAILING BY INSPECTION

Dif. lat. 225′.0 N. } = Co. N. 17° W. dist 235′.0
Dep. 70.6 W. }

| | | | | | | |
|---|---|---|---|---|---|---|
| Lat. Pro. lt. | 21° 17′ 00″ | N. | Long. Pro. lt. | | 89° 39′ 30″ | W. |
| Dif. 225′.0 = + | 3 45 00 | N. | Dif. | 77′.0 = + | 1 17 00 | W. |
| Lat. ship | 25 02 00 | N. | Long. ship | | 90 56 30 | W. |

Lat. Pro. lt. 21° 17′ 00″ N.
Lat. ship + 25 02 00 N.
2)46 19 00
Middle lat. 23 09 30

Middle lat. 23° dep. 70′.6 = dif. long. 77′.0 = 1° 17′ 00″ W.

### MERCATOR SAILING BY LOGARITHMS

| | | | |
|---|---|---|---|
| Lat. ship | — 25° 02′ 00″ N. | Mer. parts | — 1542′.3 |
| Lat. H. B. L. S. | 29 06 05 N. | Mer. parts | 1814.9 |
| Dif. 244′.1 = | 4 04 05 N. | Dif. | = 272.6 N. |

| | |
|---|---|
| Long. ship | — 90° 56′ 30″ W. |
| Long. Heald Bank L. S. | 94 12 27 W. |
| Dif. 196′.0 = | 3 15 57 W. |

| | | |
|---|---|---|
| Dif. long. | 196′.0 | 2.29226 |
| Mer. dif. | 272.6 — | 2.43553 |
| Co. N. 35° 43′ W. | = tang. | 9.85673 |

| | | |
|---|---|---|
| Co. N. 35° 43′ W. | sec. | .09049 |
| Prop. dif. lat. | 244′.1 + | 2.38757 |
| Dist. | 300.6 = | 2.47806 |

## PRACTICAL DEAD RECKONING

The traverse table is not used in the practice of navigation, but its use must be learned that more practical means may be used to keep account of a ship's track.

Usually the following method is not wanted at an examination, but should be used in practice. The former is quite satisfactory so far as the final result is concerned, which is not known until the end of the day. By this the ship's position may be known at any moment. In other words, by one the ship takes the man and by the other the man takes the ship.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lat. Pro. L. | | 21° 17′.0 N. | | | | Long. Pro. L. | | 89° 39′.5 W. |
| Dif. | + | 6.3 N. | =21° | dep. | 1′.6= | dif. | + | 1.7 W. |
| Lat. noon | | 21 23.3 N. | | | | Long. noon | | 89 41.2 W. |
| Dif. | + | 25.6 N. | =22 | dep. | 9.8= | dif. | − | 10.6 E. |
| Lat. 4 P.M. | | 21 48.9 N. | | | | Long. 4 P.M. | | 89 30.6 W. |
| Dif. | + | 24.6 N. | =22 | dep. | 21.4= | dif. | − | 23.1 E. |
| Lat. 8 P.M. | | 22 13.5 N. | | | | Long. 8 P.M. | | 89 07.5 W. |
| Dif. | + | 27.7 N. | =22 | dep. | 18.7= | dif. | + | 20.2 W. |
| Lat. Mdt. | | 22 41.2 N. | | | | Long. Mdt. | | 89 27.7 W. |
| Dif. | + | 44.3 N. | =23 | dep. | 14.8= | dif. | + | 16.1 W. |
| Lat. 4 A.M. | | 23 25.5 N. | | | | Long. 4 A.M. | | 89 43.8 W. |
| Dif. | + | 44.6 N. | =24 | dep. | 27.9= | dif. | + | 30.5 W. |
| Lat. 8 A.M. | | 24 10.1 N. | | | | Long. 8 A.M. | | 90 14.3 W. |
| Dif. | + | 53.5 N. | =25 | dep. | 17.9= | dif. | + | 19.8 W. |
| Lat. noon | | 25 03.6 N. | | | | Long. noon | | 90 34.1 W. |
| Dif. (current) | − | 1.6 S. | =25 | dep. | 20.9= | dif. (current) | + | 23.1 W. |
| Lat. noon | | 25 02.0 N. | | | | Long. noon | | 90 57.2 W. |

The result is two noon positions, the first without considering the current, which in the other is taken into account.

The current could be considered on each course, but such a degree of precision is seldom necessary.

The ship's position differs slightly from that found by the preceding method, but is quite near enough to meet the demands of practice.

| | | | |
|---|---|---|---|
| Lat. Pro. L. | — 21° 17'.0 N. | Long. Pro. L. | — 89° 39'.5 W. |
| Lat. ship | 25 02 .0 N. | Long. ship | 90 57 .2 W. |
| Dif. | 225'.0 = 3 45 .0 N. | Dif. | 77'.7 = 1 17 .7 W. |

Mid. lat. 23° dif. long. 77'.7 = dep. 71'.8

$\left.\begin{array}{ll}\text{Dif. lat.} & 225'.0\text{ N.}\\ \text{Dep.} & 71.8\text{ W.}\end{array}\right\} = \text{Co. N. } 18^\circ \text{ W. dist. } 237'.0$

| | | | |
|---|---|---|---|
| Lat. ship | — 25° 02'.0 N. | Long. ship | — 90° 57'.2 W. |
| Lat. H. B. L. S. | 29 06 .1 N. | Long. H. B. L. S. | 94 12 .4 W. |
| Dif. | 244'.1 = 4 04 .1 N. | Dif. | 195'.2 = 3 15 .2 W. |

Mid. lat. 27° dif. long. 195'.2 = dep. 173'.7

$\left.\begin{array}{ll}\text{Dif. lat.} & 244'.1\text{ N.}\\ \text{Dep.} & 173.7\text{ W.}\end{array}\right\} = \text{Co. N. } 35^\circ \text{ W. dist. } 298'.0$

By this method the distance is in error about 1'.4, which is quite satisfactory in practice. However, the distance found by Mercator sailing by inspection is in error by about the same quantity, which at once indicates that logarithms should be used in place of the inspection method.

# FOR THE STUDENT

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## 67, 35. The Log and Line.

This instrument is now known as the "old-fashioned log" on account of the logs in use now, having taken its place generally; but strange as it may seem, the old method of ascertaining the speed is still in use on board some ships. While it is not so convenient as the instruments more generally used for the purpose, it gives the speed correctly at the time it is used.

With its many disadvantages, it has one important advantage over the logs now used. That is, owing to its simplicity, one can be very easily and quickly made in case the modern log could not be had; a circumstance that most any officer is liable to encounter, and for that reason it is necessary that every officer should know how to make and use the "old-fashioned log."

The contrivance is composed of the log chip, line, reel and glass. The second hand of a watch may be used in place of the glass.

### The Log Chip.

This part of the instrument consists of a quadrantal piece of thin board about seven inches radius, the curved side of which is loaded with lead to make it float upright. One hole is in each corner of the chip, and through the upper one the log line is rove and knotted. . Both ends of a piece of line about ten feet long the same size as the log line are rove through the two lower holes and form a bridle. Exactly in the middle of the bridle a toggle is seized and this toggle fits into a socket seized on to the log line at the same distance from the chip as the toggle is.

The object of this toggle and socket is to reduce the labor of hauling the chip in, as the toggle will pull out as soon as the line is checked, which is done as soon as the glass runs out. The chip will then lie flat on the water and very little strain will be on the line.

## The Time Glass.

The time glass may be for any number of seconds. Those used are fourteen, twenty-eight and thirty seconds. It is not uncommon to find a time glass in error a second or two, which may be determined by comparison with the second hand of a chronometer or watch. When the sand in the glass is dry, it will run faster than when damp. Usually it will be dry or damp according to the weather, a matter that must be considered.

## The Log Line.

The line is marked off at certain intervals, the length of which depending on the number of seconds in the glass used.

Measuring from the chip, allow about fifteen fathoms for stray line, and put in a red rag as a mark. From this mark the knots are measured. Their lengths are as follows:

For a fourteen second glass, the length of a knot is twenty-three feet and seven and three quarter inches.

For a twenty-eight second glass, the length of a knot is forty-seven feet and three and one half inches.

For a thirty second glass, the length of a knot is fifty feet and eight inches nearly.

The line is measured and marked when wet and tested by frequent measurement.

Put one knot in the first mark, two in the second and so on. For half knots use a piece of cod line without any knots.

If the line is marked for a twenty-eight second glass and a fourteen second glass is used, it is only necessary to double the number of knots run out to get the speed.

The length of knot is found on page forty-eight, by using logarithms and the following shows the same result without their use.

The proportion is—As the number of seconds (3600) in an hour is to the number of feet (6080) in a nautical mile, so is the number of seconds (14, 28 or 30) in the glass to the number of feet in a knot.

### Fourteen Second Glass.

```
         6080
           14
       ------
        24320
        6080
       ------
3600 ) 85120 ( 23.64
       7200      × 12
       -----     ----
       13120      128
       10800      64
       -----     ----
        23200    7.68 = 7¾ inches, nearly.
        21600
        -----
         16000
         14400
         -----
          1600
```

The length of a knot for a fourteen second glass is 23.64 feet = 23 feet 7¾ inches nearly.

### Twenty Eight Second Glass.

```
         6080
           28
        -----
        48640
       12160
      -------
3600 ) 170240 ( 47.29
       14400     × 12
       -----     ----
        26240      58.
        25200    29
        -----    ----
         10400   3.48 = 3½ inches, nearly.
          7200
         -----
          32000
          32400
          -----
            400
```

The length of a knot for a twenty-eight second glass is 47.29 feet = 47 feet 3½ inches nearly.

## Thirty Second Glass.

$$\begin{array}{rl}
6080 & \\
30 & \\
\cline{1-1}
3600\,)\,182400\,( & 50.66 \\
18000 & \times 12 \\
\cline{1-2}
24000 & 132 \\
21600 & 66 \\
\cline{1-2}
24000 & 7.92 = 8 \text{ inches, nearly.} \\
21600 & \\
\cline{1-1}
2400 &
\end{array}$$

The length of a knot for a thirty second glass is 50.66 feet = 50 feet 8 inches nearly.

This log is hove from the lee quarter and as soon as the red rag is on the taffrail, the glass is turned and the speed of the ship will be the number of knots run over the rail while the sand in the glass runs down.

The examiner does not as a rule require the applicant to perform this calculation. The answer to the question as given on page 29, is all that is necessary.

*Lighthouse* ........................................ ✸

*Lighthouse on small scale chart* • *Old light tower* .................. ●

*Beacon, lighted* .................. ★ *Beacon, not lighted* .................. ▲

*Spindle (or stake)* .................. ǀ *add word Spindle if space allows*

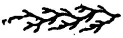
*Lightship* ........................................ ✹

*Anchorage* .................. ⚓ *Wreck* .................. -+-

*Rock awash at low water* ....... ✱ *Sunken rock* .................. +

*Life Saving Station* ........... ◆ *L.S.S.* (T) .......... *signifies connection with telegraphic system.*

*Kelp* ........................................



*No bottom at 20 fathoms* .................. $\overset{\circ}{\overline{20}}$ *etc*

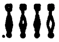
*Red buoy* ⬯ *or add word white or yellow as required.*

*Black buoy* ........................................ ⬮

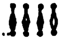
*Horizontally striped buoy* ........................................ ⬮

*Perpendicularly striped buoy* ........................................ ⬮

*Buoys with perch and square* ........................................



*Buoys with perch and ball* ........................................



*Lighted buoy* .................. ✸ *in place of* •, *as* .................. ⬯✸ *etc.*

*Mooring buoy* ........................................ ⬬

*Landmark, as Cupola, Standpipe, etc.* ........................................ ○

*Whirlpool* ........................................ ●

*Tide rip* ........................................ ≈≈≈

*Current, not tidal, drift in knots as* .................. ≫—— 2.0 ——→

" *, flood, first quarter, drift in knots, as* .......... —— 0.4 ——+→

" " " *, second* " " " " " .......... —— 1.0 ——++→

" " " *, third* " " " " " .......... —— 0.3 ——+++→

" *, ebb,* .................. ———————— *otherwise like the flood.*

## FOR CONVERTING NAUTICAL MILES INTO STATUTE MILES.

| Nautical miles. | Statute miles. | Nautical miles. | Statute miles. | Nautical miles. | Statute miles. |
|---|---|---|---|---|---|
| 1.00 | 1.151 | 8.75 | 10.075 | 16.50 | 18.999 |
| 1.25 | 1.439 | 9.00 | 10.363 | 16.75 | 19.287 |
| 1.50 | 1.727 | 9.25 | 10.651 | 17.00 | 19.575 |
| 1.75 | 2.015 | 9.50 | 10.939 | 17.25 | 19.863 |
| 2.00 | 2.303 | 9.75 | 11.227 | 17.50 | 20.151 |
| 2.25 | 2.590 | 10.00 | 11.515 | 17.75 | 20.439 |
| 2.50 | 2.878 | 10.25 | 11.803 | 18.00 | 20.727 |
| 2.75 | 3.166 | 10.50 | 12.090 | 18.25 | 21.015 |
| 3.00 | 3.454 | 10.75 | 12.378 | 18.50 | 21.303 |
| 3.25 | 3.742 | 11.00 | 12.666 | 18.75 | 21.590 |
| 3.50 | 4.030 | 11.25 | 12.954 | 19.00 | 21.878 |
| 3.75 | 4.318 | 11.50 | 13.242 | 19.25 | 22.166 |
| 4.00 | 4.606 | 11.75 | 13.530 | 19.50 | 22.454 |
| 4.25 | 4.893 | 12.00 | 13.818 | 19.75 | 22.742 |
| 4.50 | 5.181 | 12.25 | 14.106 | 20.00 | 23.030 |
| 4.75 | 5.469 | 12.50 | 14.393 | 20.25 | 23.318 |
| 5.00 | 5.757 | 12.75 | 14.681 | 20.50 | 23.606 |
| 5.25 | 6.045 | 13.00 | 14.969 | 20.75 | 23.893 |
| 5.50 | 6.333 | 13.25 | 15.257 | 21.00 | 24.181 |
| 5.75 | 6.621 | 13.50 | 15.545 | 21.25 | 24.469 |
| 6.00 | 6.909 | 13.75 | 15.833 | 21.50 | 24.757 |
| 6.25 | 7.196 | 14.00 | 16.121 | 21.75 | 25.045 |
| 6.50 | 7.484 | 14.25 | 16.409 | 22.00 | 25.333 |
| 6.75 | 7.772 | 14.50 | 16.696 | 22.25 | 25.621 |
| 7.00 | 8.060 | 14.75 | 16.984 | 22.50 | 25.909 |
| 7.25 | 8.348 | 15.00 | 17.272 | 22.75 | 26.196 |
| 7.50 | 8.636 | 15.25 | 17.560 | 23.00 | 26.484 |
| 7.75 | 8.924 | 15.50 | 17.848 | 23.50 | 27.060 |
| 8.00 | 9.212 | 15.75 | 18.136 | 24.00 | 27.636 |
| 8.25 | 9.500 | 16.00 | 18.424 | 24.50 | 28.212 |
| 8.50 | 9.787 | 16.25 | 18.712 | 25.00 | 28.787 |

One nautical mile=6080 feet.

## FOR CONVERTING STATUTE MILES INTO NAUTICAL MILES.

| Statute miles. | Nautical miles. | Statute miles | Nautical miles. | Statute miles. | Nautical miles. |
|---|---|---|---|---|---|
| 1.00 | 0.868 | 9.00 | 7.815 | 17.00 | 14.763 |
| 1.25 | 1.085 | 9.25 | 8.032 | 17.25 | 14.980 |
| 1.50 | 1.302 | 9.50 | 8.249 | 17.50 | 15.197 |
| 1.75 | 1.519 | 9.75 | 8.467 | 17.75 | 15.414 |
| 2.00 | 1.736 | 10.00 | 8.684 | 18.00 | 15.632 |
| 2.25 | 1.953 | 10.25 | 8.901 | 18.25 | 15.849 |
| 2.50 | 2.170 | 10.50 | 9.118 | 18.50 | 16.066 |
| 2.75 | 2.387 | 10.75 | 9.335 | 18.75 | 16.283 |
| 3.00 | 2.604 | 11.00 | 9.552 | 19.00 | 16.500 |
| 3.25 | 2.821 | 11.25 | 9.769 | 19.25 | 16.717 |
| 3.50 | 3.038 | 11.50 | 9.986 | 19.50 | 16.934 |
| 3.75 | 3.256 | 11.75 | 10.203 | 19.75 | 17.151 |
| 4.00 | 3.473 | 12.00 | 10.420 | 20.00 | 17.369 |
| 4.25 | 3.690 | 12.25 | 10.638 | 20.25 | 17.586 |
| 4.50 | 3.907 | 12.50 | 10.855 | 20.50 | 17.803 |
| 4.75 | 4.124 | 12.75 | 11.072 | 20.75 | 18.020 |
| 5.00 | 4.341 | 13.00 | 11.289 | 21.00 | 18.237 |
| 5.25 | 4.559 | 13.25 | 11.507 | 21.25 | 18.454 |
| 5.50 | 4.776 | 13.50 | 11.724 | 21.50 | 18.671 |
| 5.75 | 4.994 | 13.75 | 11.941 | 21.75 | 18.888 |
| 6.00 | 5.211 | 14.00 | 12.158 | 22.00 | 19.105 |
| 6.25 | 5.428 | 14.25 | 12.376 | 22.25 | 19.322 |
| 6.50 | 5.645 | 14.50 | 12.593 | 22.50 | 19.539 |
| 6.75 | 5.862 | 14.75 | 12.810 | 22.75 | 19.756 |
| 7.00 | 6.079 | 15.00 | 13.027 | 23.00 | 19.973 |
| 7.25 | 6.296 | 15.25 | 13.244 | 23.25 | 20.191 |
| 7.50 | 6.513 | 15.50 | 13.461 | 23.50 | 20.408 |
| 7.75 | 6.730 | 15.75 | 13.678 | 23.75 | 20.625 |
| 8.00 | 6.947 | 16.00 | 13.895 | 24.00 | 20.842 |
| 8.25 | 7.164 | 16.25 | 14.112 | 24.25 | 21.060 |
| 8.50 | 7.381 | 16.50 | 14.329 | 24.50 | 21.277 |
| 8.75 | 7.598 | 16.75 | 14.546 | 25.00 | 21.711 |

**One statute mile=5280 feet.**

## INTERNATIONAL CODE.

This code consists of 27 flags, as follows : 2 burgees, 5 pennants, 19 square flags and the code pennant, making 27 in all, and are described as follows :

Code pennant, red and white in 5 alternate stripes.

### Burgees.

| | |
|---|---|
| *A* | White—blue, in two vertical stripes. |
| *B* | Red. |

### Pennants.

| | |
|---|---|
| *C* | White with red spot. |
| *D* | Blue with white spot. |
| *E* | Red—white—blue, in three vertical stripes. |
| *F* | Red, with white right cross. |
| *G* | Yellow—blue, in two vertical stripes. |

### Square Flags.

| | |
|---|---|
| *H* | White—red, in two vertical stripes. |
| *I* | Yellow, with black spot in centre. |
| *J* | Blue—white—blue, in three horizontal stripes. |
| *K* | Yellow—blue, in two vertical stripes. |
| *L* | Blue and yellow in four alternate checks. |
| *M* | Blue, with white diagonal cross. |
| *N* | Blue and white in sixteen alternate checks. |
| *O* | Yellow and red in two diagonal stripes. |
| *P* | Blue with white centre. |
| *Q* | Yellow—Quarantine. |
| *R* | Red with yellow right cross. |
| *S* | White with blue centre. |
| *T* | Red—white—blue in three vertical stripes. |
| *U* | Red and white in four alternate checks. |
| *V* | White with red diagonal cross. |
| *W* | Blue—white—red in three borders. |
| *X* | White, with blue right cross. |
| *Y* | Yellow and red in ten diagonal stripes. |
| *Z* | Black—yellow—blue—red, each color triangular shaped. |

To open communication, show the ensign with the Code Pennant under it.

When using the Code Pennant as an Answering Pennant, hoist it by itself where best seen.

# EXTRACT OF THE

# GENERAL RULES AND REGULATIONS

PRESCRIBED BY THE

# BOARD OF SUPERVISING INSPECTORS

## ORIGINAL LICENSES.

1. Before an original license is issued to any person to act as a master, mate, pilot, or engineer he shall personally appear before some local board or a supervising inspector for examination. Any person who has attained the age of 19 years and has had the necessary experience shall be eligible for examination: *Provided,* That no person shall receive a license as master or chief engineer before reaching the age of 21 years.

Inspectors shall, before granting an original license to any person to act as an officer of a vessel, require the applicant to make written application upon the blank form furnished by the Department of Commerce, to be filed in the inspectors' office. When practicable, applicants for master's, mate's, pilot's, or engineer's license shall present to the inspectors, to be filed with their application, discharges or letters from the master or other officer under whom they have served, certifying to the name of the vessel and in what capacity the applicant has served under him; also period of such service. Inspectors shall also, when practicable, require applicant for pilot's license to have the written indorsement of the master and engineer of the vessel upon which he has served, and of one licensed pilot, as to his qualifications. In the case of applicants for original engineer's license, they shall also, when practicable, have the indorsement of the master and engineer of a vessel on which they have served, together with one other licensed engineer.

The first license issued to any person by a United States inspector shall be considered an original license, where the United States records show no previous issue to such applicant.

No original license shall be issued to any naturalized citizen on less experience in any grade than would have been required of a citizen of the United States by birth. (Sec. 4405, R. S.)

## VISUAL EXAMINATIONS REQUIRED FOR ORIGINAL AND RENEWED LICENSES.

2. No original license as master, mate, or pilot of any vessel

propelled in whole or in part by steam, gas, fluid, naphtha, alco-vapor, electric, or other like motors, or master or mate of sail vessels, shall be issued except upon the official certificate of a surgeon of the Public Health Service respecting the vision of the person applying for such original license. The word "original" as contemplated in this section shall mean the first license of any character issued to a master, mate, or pilot, and shall not be held to mean, for instance, that a license issued to a master who was previously licensed as a mate or pilot shall be considered an original master's license.

No license as master, mate, or pilot of any class of vessel specified and enumerated in the foregoing paragraph shall be renewed except upon the official certificate of a surgeon of the Public Health Service that the color sense of the applicant for renewal is normal.

Where an applicant for renewal of license is situated so that it would put him to great inconvenience or expense to appear before a surgeon of the Public Health Service for examination, the certificate of a reputable physician or oculist as to the color sense of the applicant shall be accepted in lieu of the certificate of the surgeon of the Public Health Service.

In case an applicant for original license or renewal of license is pronounced color-blind he may, in the discretion of the inspectors, be limited to act as master, mate, or pilot on a vessel navigating in daylight only.

Any applicant for renewal of license who has been refused such renewal on account of the requirements of section 48, Rule V, as amended in January, 1911, respecting visual acuity and color sense, may apply for renewal of license under the provisions of the foregoing section, and nothing herein contained shall debar an applicant who has lost the sight of one eye from securing a renewal of his license, providing that his color sense is normal. (Secs. 4439, 4440, 4442, R. S.)

### EXAMINATIONS.

3. No original master's, mate's, pilot's, or engineer's license

shall be issued hereafter or grade increased except upon written examination by a board of local inspectors or a supervising inspector, which written examination shall be placed on file in the office of the inspectors issuing said license: *Provided, however,* That upon navigable waters of the United States newly opened to steamboat navigation, and where the only pilots obtainable are illiterate Indians or other natives, the fact that such persons can neither read nor write shall not be considered a bar to such Indians or other natives receiving license as pilot of steam vessels, provided they are otherwise qualified therefor.

Before granting or renewing a license, inspectors shall satisfy themselves that the applicants can properly hear the bell and whistle signals.

When any person makes application for license it shall be the duty of the local inspectors to give the applicant the required examination as soon as practicable. (Secs. 4405, 4439, 4440, 4441, 4442, R. S.)

### REEXAMINATIONS AND REFUSAL OF LICENSES.

4. Any applicant for license who has been duly examined and refused may come before the same local board for reexamination at any time thereafter, but he shall not be examined by any other local board until one year has expired from the date of the refusal.

If the inspectors shall decline to grant the applicant the license asked for, they shall furnish him a statement, in writing, setting forth the cause of their refusal to grant the same. (Sec. 4405, R. S.)

### PREPARATION OF LICENSES.

5. All licenses hereafter issued to masters, mates, pilots, and engineers shall be filled out on the face with pen and black ink instead of typewritten. Inspectors are directed, when licenses are completed, to draw a broad pen and black-ink mark through all unused spaces in the body thereof, so as to prevent, as far as possible, illegal interpolation after issue. (Sec. 4405, R. S.)

### CERTIFICATE OF LOST LICENSE.

6. In case of loss of license, of any class, from any cause, the inspectors, upon receiving satisfactory evidence of such loss, shall issue a certificate to the owner thereof, which shall have the authority of the lost license for the unexpired term, unless in the meantime the holder therof shall have the grade of his license raised, after due examination, in which case a license in due form for such grade may be issued. (Sec. 4405, R. S.)

### PARTING WITH LICENSE.

7. Any license granted to a master, mate, pilot, engineer, or operator shall be immediately revoked if, for any purpose, the holder thereof voluntarily parts with its possession or places it beyond his personal control by pledging or depositing it with another. (Sec. 4405, R. S.)

### RENEWAL OF LICENSES.

8. Whenever an officer shall apply for a renewal of his license for the same grade, the presentation of the old license, with satisfactory certificate of visual examination, where required, and with oath of office, shall be considered sufficient evidence in his title to renewal, which old license, certificate of visual examination, and oath of office shall be retained by the inspectors upon their official files as the evidence upon which the license was renewed: *Provided,* That it is presented within 12 months after the date of its expiration, unless such title has been forfeited or facts shall have come to the knowledge of the inspectors which would render a renewal improper; nor shall any license be renewed more than 30 days in advance of the date of the expiration thereof, unless there are extraordinary circumstances that shall justify a renewal beforehand, in which case the reasons therefor must appear in detail upon the records of the inspectors renewing the license.

Whenever an officer shall apply for renewal of his license for same grade, after 12 months after date of its expiration, he shall be required to pass an examination for the same grade of license. The renewed license in either case shall receive the next higher number for number of issue of present grade and for number of issues of all grades.

Whenever a license officer makes application for a renewal of his license, he shall appear in person before some board of local inspectors or supervising inspector, except that upon renewal of such license for the same grade, when the distance from any local board or supervising inspector is such as to put the person holding the same to great inconvenience and expense to appear in person, he may, upon taking oath of office before any person authorized to administer oaths, and forwarding the same, together with the license to be renewed and certificate of visual examination where required, to the local board or supervising inspector of the district in which he resides or is employed, have the same renewed by the said inspectors, if no valid reason to the contrary be known to them; and they shall attach such oath to the stub end of the license, which is to be retained on file in their office: *Provided, however*, That any officer holding a license, and who is engaged in a service which necessitates his continuous absence from the United States, may make application in writing for renewal and transmit the same to the board of local inspectors, with his certificate of citizenship, if naturalized, and a statement of the applicant, verified before a consul or other officer of the United States authorized to administer an oath, setting forth the reasons for not appearing in person; and upon receiving the same the board of local inspectors that originally issued such license shall renew the same and shall notify the applicant of such renewal, and no license as master, mate, or pilot of any class or vessel shall be renewed without furnishing a satisfactory certificate of color blindness. (Secs. 4405, 4438, R. S.)

### EXTENSION OF ROUTE AND RAISE OF GRADE OF LICENSES.

9. Licensed officers serving under five years' license, entitled by license and service to raise of grade, shall have issued to them

new licenses for the grade for which they are qualified, the local inspectors to file in their office the old license when surrendered, with the report of the circumstances of the case, after the old license and report of the circumstances of the case shall have been reviewed by the supervising inspector of the district, but the grade of no license shall be raised, except as hereinafter provided, unless the applicant can show one year's actual experience in the capacity for which he has been licensed.

Inspectors shall, before granting an extension of route or raise of grade of license, require the applicant to make his written application upon the blank form of application for extension of route or raise of grade of license furnished by the department. When practicable, applicants for extension of route or raise of grade of license shall present to the inspectors, to be filed with the application, discharges or letters from the master or other officer under whom they have served, or other satisfactory documentary evidence, certifying to the name of the vessel and in what capacity the applicant has served; also period of such service.

If any board of local inspectors is satisfied that a pilot is entitled by experience and knowledge to unlimited tonnage they may remove any tonnage restrictions which may have been placed upon his license by any other board of local inspectors.

Practical service in the deck department of an ocean or coastwise vessel propelled by machinery shall be accepted when offered in documentary evidence by any person applying for an original license or raise of grade as equal to the same amount of service in any ocean or coastwise steam passenger vessel.

Service on United States motor-propelled light vessels or lighthouse tenders shall be considered as equivalent experience for raise of grade as that obtained on vessels subject to inspection by this Service. (Sec. 4405, R. S.)

### EXAMINATION OF CANCELED LICENSES BY SUPERVISING INSPECTORS.

10. With the exception of operators' licenses, every canceled license renewed, with or without raise of grade, and every can-

celed license for which a license of a higher grade is issued before the expiration of the five years' term of license shall be submitted to the supervising inspector of the district for his review, to determine whether both licenses have been issued in accordance with the rules and regulations and whether they are in proper form. The supervising inspector shall personally, carefully examine every canceled license submitted to him. The canceled license shall be promptly examined by the supervising inspector and returned to the local inspectors. (Secs. 4405, R. S.)

### EXAMINATION FOR RENEWAL OF MASTER'S OF PILOT'S LICENSE.

11. It shall be the duty of all inspectors, before renewing an existing license to a master or pilot of steam vessels, for any waters, who has not been employed as master or pilot on such waters during the three years preceding the application for renewal, to satisfy themselves, by an examination in writing, or orally, to be taken down in writing by the inspectors, that such officers are thoroughly familiar with the pilot rules upon the waters for whch they are licensed. (Secs. 4439, 4442, R. S.)

### LAWS, GENERAL RULES AND REGULATIONS, AND PILOT RULES TO BE FURNISHED LICENSED OFFICERS.

12. Every master, mate, pilot, and engineer of vessels shall, when receiving an original license, a renewed license, or a raise of grade of license, be furnished by the inspectors with a copy of the Laws Governing the Steamboat-Inspection Service, and a copy of the General Rules and Regulations Prescribed by the Board of Supervising Inspectors, and every master and pilot of vessels and operator of motor vessels shall, when receiving an original license, a renewed license, or a raise of grade of license, be furnished by the inspectors with a pamphlet copy of the rules and regulations governing pilots and of the statutes upon which such rules are founded, applicable to the waters on which their licenses are intended to be used, as stated in the body thereof. (Sec. 4405, R. S.)

### SUSPENSION AND REVOCATION OF LICENSES.

13. When the license of any master, mate, pilot, or engineer is revoked such license expires with such revocation, and any license subsequently granted to such person shall be considered in the light of an original license except as to number of issue. And upon the revocation or suspension of the license of any such officer said license shall be surrendered to the local inspectors ordering such suspension or revocation.

When the license of any master, mate, engineer, or pilot is suspended, the inspectors making such suspension shall determine the term of its duration, except that such suspension shall not extend beyond the time for which the license was issued.

The suspension or revocation of a joint license shall debar the person holding the same from the exercise of any of the privileges therein granted, so long as such suspension or revocation shall remain in force. (Sec. 4450, R. S.)

### MISCONDUCT OF LICENSED OFFICERS.

14. Whenever a supervising, local, or assistant inspector of steam vessels, or any of them, shall find on board any vessel subject to the provisions of Title LII of the Revised Statutes any licensed officer under the influence of liquor or other stimulant to such an extent as to unfit him for duty, or when any licenced officer shall use abusive or insulting language to any inspector or assaults any such inspector while on official duty, the local inspectors or the supervising inspector shall immediately suspend or revoke the license of the officer so offending without further trial or investigation.

The fact of a licensed officer being under the influence of liquor in the presence of the inspector or inspectors to such an extent as to unfit him for duty while on board a vessel shall be sufficient cause for such suspension or revocation. (Secs. 4405, 4450, R. S.)

### LICENSES TO OFFICERS OF VESSELS OWNED BY THE UNITED STATES.

15. Any person who has served at least one year as master,

commander, pilot, or engineer of any steam vessel owned and operated by the United States in any service in which a license as master, mate, pilot, or engineer was not required at the time of such service, shall be entitled to license as master, mate, pilot, or engineer, if the inspectors, upon written examination, as required for applicants for orginal license, may find him qualified: *Provided*, That the experience of any such applicant within three years of making application has been such as to qualify him to serve in the capacity for which he makes application to be licensed. (Secs. 4439, 4440, 4441, 4442, R. S.)

### REPORTS OF ACCIDENTS TO VESSELS.

16. The licensed officer in command of any vessel subject to the inspection of the Steamboat-Inspection Service shall report in writing and in person to the board of local inspectors nearest the port of first arrival any accident to said vessel involving loss of life, or damage to property to an approximate amount exceeding $100, and shall also report in the same manner any casualty or loss of life from whatever cause of any person on board such vessel. If the accident happens upon the high seas or without the jurisdiction of inland waters, the board to whom the report is first made shall make the investigation, but if the accident occurs within the jurisdiction of inland waters, the report shall be transmitted to the board within whose jurisdiction the accident occurred, which board shall make the investigation except in cases where, in the judgment of the Supervising Inspector General, better results may be obtained by another board conducting the investigation, in whch case the Supervising Inspector General is authorized to direct such investigation by another board: *Provided,* That when from distance it may be inconvenient to report in person it may be done in writing only, and the report sworn to before any person authorized to administer oaths.

Whenever a vessel subject to the inspection of the Steamboat-Inspection Service collides with lightship, buoy, or other aid to navigation under the jurisdiction of the Bureau of Lighthouses, or is connected with any such collision, it shall be the duty of the licensed officer in command of such vessel to report the accident to the nearest board of local inspectors. When any collision of this character is reported to a board of local inspectors, those officers shall immediately transmit such information to the lighthouse inspector of the district in which the collision occurred. (Secs. 4405, 4448, R. S.)

### ONLY CERTAIN PERSONS ALLOWED IN PILOT HOUSE AND ON NAVIGATOR'S BRIDGE.

17. Masters and pilots of steamers carrying passengers shall exclude from the pilot houses and navigator's bridge of such steamers, while under way, all persons not connected with the navigation of such steamers, except officers of the Steamboat-Inspection Service, Coast Guard, and engineer officers of the United States Army in charge of the improvement of that particular waterway, when upon business: *Provided,* That licensed officers of steamboats, persons regularly engaged in learning the profession of pilot, officers of the United States Navy, United States Coast and Geodetic Survey, and Lighthouse Service, assistant engineers of the Engineer Department of the United States Army connected with the improvement of that particular waterway, and the engineer officers connected with the construction and operation of the Panama Canal may be allowed in the pilot house or upon the navigator's bridge upon the responsibility of the officer in charge.

The master of every such passenger and ferry steamer shall keep three printed copies of this section of Rule V posted in conspicuous places on such steamer, one of which shall be kept posted in the pilot house.

Such printed copies shall be furnished by the Department of Commerce to local inspectors for distribution. (Sec. 4405, R. S.)

### STATION BILLS, DRILLS, AND REPORTS OF MASTERS.

18. It shall be the duty of the officer in charge of every

steamer carrying passengers to cause to be prepared a station bill for his own department, and one also for the engineer's department, in which shall be assigned a post or station of duty for every person employed on board such steamer in case of fire or other disaster, which station bills shall be placed in the most conspicuous places on board for the observation of the crew. And it shall be the duty of such master, or of the mate or officer next in command, once at least in each week, to call all hands to quarters and exercise them in the discipline, and in the unlashing and swinging out of the lifeboats, weather permitting, and in the use of the fire pumps and all other apparatus for the safety of life on board of such vessel, with especial regard for the drill of the crew in the method of adjusting life preservers and educating passengers and others in this procedure and to see that all the equipments required by law are in complete working order for immediate use; and the fact of the exercise of the crew, as herein contemplated, shall be entered upon the steamer's log book, stating the day of the month and hour when so exercised; and it shall be the duty of the inspectors to require the officers and crew of all such vessels to perform the aforesaid drills and discipline in the presence of the said inspectors at intervals sufficiently frequent to assure the said inspectors by actual observation that the foregoing requirements of this section are complied with; the master shall also report monthly to the local inspectors the day and date of such exercise and drill, the condition of the vessel and her equipment, and also the number of passengers carried, and any neglect or omission on the part of the officer in command of such steamer to strictly enforce this rule shall be deemed cause for the suspension or revocation of the license of such officer.

The *general* fire-alarm signal shall be a continuous rapid ringing of the ship's bell for a period of not less than 20 seconds, and this signal shall not be used for any other purpose whatsoever. The master of any steamer carrying passengers may establish such other emergency signals in addition to the ringing of the ship's bell, as will provide that all the officers and all the crew of the steamer will have positive and certain notice of the existing emergency.

Three copies of this section shall be furnished every steamer carrying passengers, to be framed under glass and posted in conspicuous places about the vessel. (Sec. 4405, R. S.)

### VESSELS REQUIRING LICENSED MASTERS.

19. There shall be a duly licensed master on board every steam vessel of more than 150 gross tons whenever such steamer is underway, and also upon every ocean and coastwise seagoing merchant vessel of the United States propelled by machinery, and upon every ocean-going vessel carrying passengers, subject to the inspection laws of the United States. (Secs. 4439, 4463, R. S.)

### MASTERS OF OCEAN STEAM VESSELS.

20. Any applicant for license as master of ocean steam vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. Three years' experience in the deck department on ocean steam vessels, one year of which has been as chief mate of ocean steam vessels.

Second. Or one years' experience as chief mate of ocean steam vessels of 1,000 gross tons or upward. If applicant has served part of one year as such chief mate, experience in the next lower grade, while holding chief mate's license, shall be counted one-half in computing experience.

Third. Or two years' experience in the capacity of second mate, or watch officer actually in charge of a bridge watch, on steam vessels, while holding a license as chief mate of ocean steam vessels.

Fourth. Or five years' experience as third mate of ocean steam vessels, two years of such time having been served while holding a license as chief mate of ocean steam vessels.

Fifth. Or five years's experience on ocean sail vessels of 300 gross tons or upward, two years of which shall have been as a licensed master of sail vessels.

Sixth. Or one year as master of coastwise steam vessels.

Seventh. Or one year as chief mate of coastwise steam vessels while holding license as master of coastwise steam vessels or license as chief mate of ocean steam vessels.

Any applicant for license as master of ocean steam vessels shall be subjected to such examination as shall satisfy the inspectors that he is capable of navigating such vessels and of determining latitude from the meridian altitude of the sun, latitude by ex-meridian altitude of the sun, latitude from the meridian altitude of a star, latitude by the pole star, longitude by a. m. and p. m. chronometer time sights, longitude by sunrise or sunset sights, ship's position by Sumner's method, ship's position by traverse sailing, including the correction of courses for leeway, current, deviation, and variation, one of which courses to be a departure course, and of finding course and distance by Mercator's sailing, and be capable of determining the deviation of the compass by an amplitude and azimuth, and the time of high water at a port named; he must also be familiar with charts and chart navigation, storm signals, international code of signals, and with the use of the gun and rocket apparatus for saving life from shipwreck as practiced by the United States Live-Saving Service. (Sec. 4439, R. S.)

### MASTERS OF COASTWISE STEAM VESSELS.

21. Any applicant for license as master of coastwise steam vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. Three years' experience in the deck department on ocean or coastwise steam vessels, one year of which has been chief mate of ocean or coastwise steam vessels.

Second. Or one year's experience as chief mate of ocean or coastwise steam vessels of 1,000 gross tons or upward. If applicant has served part of one year as such chief mate, experience in the next lower grade, while holding chief mate's license, shall be counted one-half in computing experience.

Third. Or two years' experience as second mate, or watch officer actually in charge of a bridge watch on ocean or coastwise steam vessels, while holding license as chief mate.

Fourth. Or five years' experience as third mate of ocean or coastwise steam vessels, two years of such time having been served while holding a license as chief mate of ocean or coastwise steam vessels.

Fifth. Or one year's experience as master of lake, bay, or sound steam vessels, and also one year's experience as quartermaster or wheelsman on ocean or coastwise steam vessels while holding a license as master of lake, bay, or sound steam vessels, which experience shall have been obtained within the three years next preceding the date of application.

Sixth. Or five years' experience on ocean or coastwise sail vessels of 300 gross tons or upward, two years of which shall have been as a licensed master of sail vessels.

Any applicant for original license as master of steam vessels on coastwise waters between points on routes not exceeding 300 miles shall pass only such examination before the inspectors as shall satisfy them that he is capable of navigating such steam vessels as master.

Any applicant for original license as master of steam vessels on coastwise routes extending more than 300 miles shall pass a satisfactory examination as to his knowledge of the distance from a fixed object by bearings of same, day's work by dead reckoning, latitude at noon by the meridian altitude of the sun, latitude by the pole star, correction of courses for leeway, current, deviation, and variation, international rules for preventing collisions of vessels at sea; and he shall also be familiar with charts and chart navigation, storm signals, the marking of the lead line, and shall be subject to other nonmathematical questions as the inspectors may determine. (Sec. 4439, R. S.)

### MASTERS OF SAIL VESSELS.

22. Local inspectors may, upon due application and examina tion, license any person as master of sail vessels of over 700 gross tons, upon receipt of satisfactory documentary evidence to be filed in their office that said person has been actually employed for the full period of five years on sail vessels of 200 gross tons and upward, one year of which experience shall have been as master of sail vessels of 500 gross tons and upward or two years as master of sail vessels of 300 gross tons and upward or two years as mate of sail vessels of 500 gross tons and upward.

The examination for license as master of sail vessels of over 700 gross tons shall be such as to satisfy the inspectors that the applicant can safely navigate such vessels, and determine latitude and longitude by observations of the sun, latitude by the pole star, ship's position by traverse sailing (day's work), course and distance by Mercator's sailing, variation of the compass by amplitude and azimuth, and be familiar with charts, chart navigation, international code of signals, storm signals, and with the use of the gun and rocket apparatus for saving life from shipwreck as practiced by the United States Life-Saving Service. (Sec. 4439, R. S.)

### CHIEF MATE OF OCEAN STEAM VESSELS.

23. Any applicant for license as chief mate of ocean steam vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. One year's experience as licensed second mate of ocean steam vessels. If applicant has served part of one year as such second mate, experience in the next lower grade while holding second mate's license shall be counted one-half in computing experience.

Second. Or two years' experience as watch officer on ocean steam vessels while holding a second mate's license.

Third. Or three years' experience as a licensed third mate of ocean steam vessels of 3,500 gross tons or upward, one year of such service while holding a second mate's license.

Fourth. Or three years' actual experience as licensed master of steam vessels of 1,000 gross tons or upward on the Great Lakes.

Fifth. Or five years' experience in the deck department of sail vessels of 300 gross tons or upward, two years of which have been in the capacity of chief mate of sail vessels of 700 gross tons or upward.

### SECOND MATE OF OCEAN STEAM VESSELS.

24. Any applicant for license as second mate of ocean steam vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. One year's experience as third mate of ocean steam vessels.

Second. Or three years' experience in the deck department of ocean steam vessels, two years of which shall have been as watch officer or quartermaster.

Third. Or one year's experience in the deck department of ocean steam vessels, and two years on an ocean school ship.

Fourth. Or three years' experience in the deck department of ocean sail vessels of 300 gross tons or upward, one year of which shall have been as second mate of ocean vessels of 700 gross tons or upward.

Fifth. Or two years' experience as quartermaster on ocean steam vessels of 2,500 gross tons and upward while holding a license as third mate of ocean steamers.

Sixth. Or three years' experience as first-class seaman in the deck department of an ocean sail vessel and one year's experience in the deck department of an ocean steam vessel, for license as second mate of ocean steam vessels of 500 gross tons or under. (Sec. 4440, R. S.)

### THIRD MATE OF OCEAN STEAM VESSELS.

25. Any applicant for license as third mate of ocean steam

vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. Three years' experience on ocean or coastwise steam or sail vessels of 300 gross tons or over as cadet or able seaman.

Second. Or one year's experience on ocean or coastwise steam or sail vessels of 300 gross tons or upward, and two years' experience on an ocean school ship. (Sec. 4440, R. S.)

### EXAMINATION FOR MATES OF OCEAN STEAMERS.

26. No original license as chief mate of ocean steamers, as second mate of ocean steamers, or as third mate of ocean steamers shall be issued to any person who does not understand navigation and who is not able to determine a ship's position at sea by observation of the sun, to obtain longitude by chronometer, and to determine ship's latitude by altitude of either the sun or stars, and to determine deviation of the compass by amplitude and azimuth, ship's position by traverse sailing (day's work), including the correction of courses for leeway, current, variation, and deviation, one of such courses to be a departure course, course and distance by Mercator's sailing, and who is not familiar with charts and chart navigation, storm signals, international code of signals, and with the use of the gun and rocket apparatus for saving life from shipwreck, as practiced by the United States Life-Saving Service. Said qualifications shall be determined by an examination in writing, which examination shall be kept on file in the office of the local inspectors issuing the license. (Sec. 4440, R. S.)

### CHIEF MATE OF COASTWISE STEAM VESSELS.

27. Any applicant for license as chief mate or coastwise steam vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. One year's experience as licensed second mate of ocean or coastwise steam vessels. If applicant has served part of one year as such second mate, experience in the next lower grade while holding second mate's license shall be counted one-half in computing experience.

Second. Or one year's experience as a licensed first-class pilot of lake, bay, or sound steam vessels, and one year's experience as quartermaster or wheelsman on ocean or coastwise steam vessels while holding such license.

Third. Or two years' experience as licensed third mate of ocean or coastwise steam vessels.

Fourth. Or three years' experience in the deck department of ocean or coastwise steam vessels, for license as chief mate of coastwise steam vessels of 500 gross tons or under.

Fifth. Or two years' experience in the deck department of ocean or coastwise sail vessels and two years' experience in the deck department of ocean or coastwise steam vessels, for license as chief mate of coastwise steam vessels of 500 gross tons or under. (Sec. 4440, R. S.)

### SECOND MATE OF COASTWISE STEAM VESSELS.

28. Any applicant for license as second mate of coastwise steam vessels shall be eligible for examination after he has furnished satisfactory documentary evidence to the local inspectors that he has had the following experience:

First. One years' experience as a licensed third mate of ocean or coastwise steam vessels.

Second. Or two years' experience as quartermaster or wheelsman on ocean or coastwise steam vessels while holding a third mate's license.

Third. Or three years' experience in the deck department of ocean or coastwise steam vessels.

Fourth. Or two years' experience in the deck department of ocean or coastwise sail vessels and one year's experience in the deck department of an ocean or coastwise steam vessel.

Fifth. Or one year's experience in the deck department on ocean or coastwise steam or sail vessels of 300 gross tons or upward, and two years' experience on an ocean school ship.

Sixth. Or one year's experience as a licensed master of lake, bay, or sound steam vessels, for license as second mate or coastwise steam vessels of 500 gross tons or under.

Seventh. Or two years' experience as a licensed first-class pilot of lake, bay, or sound steam vessels, for license as second mate of coastwise steam vessels of 500 tons or under.

Eighth. Or one years' experience as a licensed first-class pilot of lake, bay, or sound steam vessels, and one years' experience in the deck department of steam vessels navigating the waters of the Atlantic or Pacific coast or oceans or the Gulf of Mexico, for license as second mate of coastwise steam vessels of 500 gross tons or under. (Sec. 4440, R. S.)

### THIRD MATE OF COASTWISE STEAM VESSELS.

29. Any applicant for license as third mate of coastwise steam vessels shall be eligible for examination after he has furnished satisactory documentary evidence to the local inspectors that he has had the following experience:

First. Three years' experience in the deck department of ocean or coastwise steam or sail vessels.

Second. Or one year's experience as a licensed first-class pilot of lake, bay, or sound steam vessels and one year's experience in the deck department of ocean or coastwise steam vessels.

Third. Or one years' experience as master of lake, bay, or sound steam vessels of 300 gross tons or over. (Sec. 4440, R. S.)

### EXAMINATIONS FOR MATES OF COASTWISE STEAM VESSELS

30. Any applicant for original license as chief mate, second mate, or third mate of steam vessels on coastwise waters between points on route not exceeding 600 miles shall pass only such examination before the inspectors as shall satisfy them that he is capable of navigating such steam vessels as chief mate, second mate, or third mate on such coastwise route. Any applicant for original license as chief mate, second mate, or third mate of steam vessels on coastwise route extending more than 600 miles shall pass a satisfactory examination before the inspectors as to his

knowledge of the distance from a fixed object by bearings of same, day's work by dead reckoning, latitude at noon by meridian altitude of the sun, international rules to prevent collisions, obtaining a course with parallel rules, marking of the lead line, and shall be subjected to such other examination of a nonmathematical character as the inspectors may determine. (Sec. 4440, R. S.)

### INDORSEMENT OF MASTER'S OR MATE'S LICENSE AS PILOT.

31. Whenever a master or mate desires to act in the double capacity of master and pilot, or mate and pilot, and furnishes the necessary evidence of his qualifications, the local inspectors shall indorse such pilot routes on the certificate of license. (Sec. 4443, R. S.)

### LICENSE OF OWNER AS MASTER OF STEAM YACHT.

32. Whenever the owner of a steam or sailing yacht of over 100 gross tons, who has had three years' experience in sailing such vessels, applies for a license authorizing him to act as master of steam yachts for coastwise and ocean navigation, the local inspectors shall examine the applicant as to his knowledge of the rules of the road, fog signals, signal lights (inland and international); the use of the lead and line; the use of the patent and chip logs, the compass, variation and deviation of the compass, the use of the drag, the use of oil during storms, bell signals between pilot house and engine room, handling of steam vessels, laws of storms, course and distance by chart, keeping the log book, middle latitude sailing, Mercator's sailing, method of obtaining latitude and longitude by dead reckoning, latitude by altitude of either the sun, moon, or stars; longitude by chronometer (time sights). Practical problems shall be given in the subjects of latitude and longitude. The examination shall be in writing, which shall be kept on file in the office of the local inspectors. If said examination is satisfactory to the local inspectors, they shall issue to the applicant a master's license authorizing him to discharge the duties of master of steam yachts, either for coastwise or ocean navigation. (Secs. 4439, 4442, R. S.)

### MASTER, MATE, AND PILOT OF STEAM PILOT, FISHING, PORTO RICAN, AND HAWAIIAN VESSELS.

33. Any applicant for original license to act as master of steam pilot boats, or of steamers navigating the waters of the whaling grounds in the Alaskan seas, or of steamers engaged exclusively in the business of whale fishing, or of steamers engaged in the Atlantic, Pacific, or Gulf coast fisheries, or of steam or sail vessels navigating between ports of the Hawaiian Islands, or between ports of the island of Porto Rico, shall have had at least three years' experience in the deck department of such steamers, which fact shall be verified by documentary evidence; and such applicant shall only be subjected to such examination as shall satisfy the inspectors that the applicant is capable of navigating such vessels: *It is provided,* That any person who has had at least five years' experience on sail vessels licensed in the fisheries of the United States, two years of which have been as master or mate of such sailing vessels, may be examined for license as master or mate of steam fishing vessels to be employed and exclusively in the Atlantic, Pacific, and Gulf coast fisheries. The license issued under this section shall state in the body thereof "for coastwise only," Pacific or Atlantic coast, as the case may be, and between what ports on either of said coasts.

*It is further provided,* That any applicant for original license who has had three years' experience in the deck department on steam pilot boats, or who has had two years' experience in the deck department on steam pilot boats and one year's experience on sail pilot boats, shall be eligible for examination for license as mate of steam pilot boats.

*It is further provided,* That said master's or mate's license may be indorsed as pilot on such inland waters on the above-named coasts as the local inspectors at the various ports may find the holder qualified to act on as pilot, after examination by the local inspectors, such examination to be in writing and preserved in the files of the inspectors' office. (Secs. 4439, 4440, 4442, R. S.)

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## INTERNATIONAL RULES.

### I.—ENACTING CLAUSE, SCOPE, AND PENALTY.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That the following regulations for preventing collisions at sea shall be followed by all public and private vessels of the United States upon the high seas and in all waters connected therewith, navigable by seagoing vessels.

Art. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river, or inland waters.

### PRELIMINARY DEFINITIONS.

In the following rules every steam vessel which is under sail and not under steam is to be considered a sailing vessel, and every vessel under steam, whether under sail or not, is to be considered a steam vessel.

The words "steam vessel" shall include any vessel propelled by machinery.

A vessel is "under way," within the meaning of these rules, when she is not at anchor, or made fast to the shore, or aground.

### II.—LIGHTS, AND SO FORTH.

The word "visible" in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere.

Article 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

### STEAM VESSELS—MASTHEAD LIGHT.

ART. 2. A steam vessel when under way shall carry—(a) On or in front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, a bright white light, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

### STEAM VESSELS—SIDE LIGHTS.

(b) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(d) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

### STEAM VESSELS—RANGE LIGHTS.

(e) A steam vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

### STEAM VESSELS WHEN TOWING.

ART. 3. A steam vessel when towing another vessel shall, in addition to her side lights, carry two bright white lights in a vertical line one over the other, not less than six feet apart, and when towing more than one vessel shall carry an additional bright white light six feet above or below such lights, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two (a), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.

Such steam vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

### SPECIAL LIGHTS.

ART. 4. (a) A vessel which from any accident is not under command shall carry at the same height as a white light mentioned in article two (a), where they can best be seen, and if a steam vessel in lieu of that light, two red lights, in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles; and shall, by day carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, two black balls or shapes, each two feet in diameter.

(b) A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as the white light mentioned in article two (a), and if a steam vessel in lieu of that light, three lights in a vertical line, one over the other, not less than six feet apart. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all around the horizon, at a distance of at least two miles. By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, three shapes not less than two feet in diameter, of which the highest and lowest shall be globular in shape and red in color, and the middle one diamond in shape and white.

(c) The vessels referred to in this article, when not making way through the water, shall not carry the side lights, but when making way shall carry them.

(d) The lights and shapes required to be shown by this article are to be taken by other vessels as signals that the vessel showing them is not under command and can not therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in article thirty-one.

### LIGHTS FOR SAILING VESSELS AND VESSELS IN TOW.

ART. 5. A sailing vessel under way and any vessel being towed shall carry the same lights as are prescribed by article two for a steam vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

### LIGHTS FOR SMALL VESSELS.

ART. 6. Whenever, as in the case of small vessels under way during bad weather, the green and red side lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

### LIGHTS FOR SMALL STEAM AND SAIL VESSELS AND OPEN BOATS.

ART. 7. Steam vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned in article two (a), (b), and (c), but if they do not carry them they shall be provided with the following lights:

First. Steam vessels of less than forty tons shall carry—

(a) In the fore part of the vessels, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in article two (a), and of such a character as to be visible at a distance of at least two miles.

(b) Green and red side lights constructed and fixed as prescribed in article two (b) and (c), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing a green light and a red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second. Small steamboats, such as are carried by seagoing vessels, may carry the white light at a less height than nine feet above the gunwale, but it shall be carried above the combined lantern mentioned in subdivision one (b).

Third. Vessels under oars or sails of less than twenty tons shall have ready at hand a lantern with a green glass on one side and a red glass on the other, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fourth. Rowing boats, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be obliged to carry the lights prescribed by article four (a) and article eleven, last paragraph.

### LIGHTS FOR PILOT VESSELS.

ART. 8. Pilot vessels when engaged on their station on pilotage duty shall not show the lights required for other vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above mentioned, have at hand, ready for use, a lantern with a green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

A steam pilot vessel, when engaged on her station on pilotage duty and in waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry, at a distance of eight feet below her white masthead light, a red light, visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry, in addition to the lights required for all pilot boats, the red light above mentioned, but not the colored side lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam vessels.

### LIGHTS, ETC., OF FISHING VESSELS.

ART. 9. Fishing vessels and fishing boats, when under way and when not required by this article to carry or show the lights hereinafter specified, shall carry or show the lights prescribed for vessels of their tonnage under way.

(a) Open boats, by which is to be understood boats not protected from the entry of sea water by means of a continuous deck, when engaged in any fishing at night, with outlying tackle extending not more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry one all-round white light.

Open boats, when fishing at night, with outlying tackle extending more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry one all-round white light, and in addition, on approaching or being approached by other vessels, shall show a second white light at least three feet below the first light and at a horizontal distance of at least five feet away from it in the direction in which the outlying tackle is attached.

(b) Vessels and boats, except open boats as defined in subdivision (a), when fishing with drift nets, shall, so long as the nets are wholly or partly in the water, carry two white lights where they can best be seen. Such lights shall be placed so that the vertical distance between them shall be not less than six feet and not more than fifteen feet, and so that the horizontal distance between them, measured in a line with the keel, shall be not less than five feet and not more than ten feet. The lower of these two lights shall be in the direction of the nets, and both of them shall be of such a character as to show all around the horizon, and to be visible at a distance of not less than three miles.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the net or gear) a white light, visible at a distance of not less than one sea mile, on the approach of or to other vessels.

(c) Vessels and boats, except open boats as defined in subdivision (a), when line fishing with their lines out and attached to or hauling their lines, and when not at anchor or stationary within the meaning of subdivision (h), shall carry the same lights as vessels fishing with drift nets. When shooting lines, or fishing with towing lines, they shall carry the lights prescribed for a steam or sailing vessel under way, respectively.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the lines) a white light, visible at a distance of not less than one sea mile on the approach of or to other vessels.

(d) Vessels when engaged in trawling, by which is meant the dragging of an apparatus along the bottom of the sea—

First. If steam vessels, shall carry in the same position as the white light mentioned in article two (a) a tri-colored lantern so constructed and fixed as to show a white light from right ahead to two points on each bow, and a green light and a red light over an arc of the horizon from two points on each bow to two points abaft the beam on the starboard and port sides, respectively; and not less than six nor more than twelve feet below the tri-colored lantern a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon.

Second. If sailing vessels, shall carry a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon, and shall also, on the approach of or to other vessels, show where it can best be seen a white flare-up light or torch in sufficient time to prevent collision.

All lights mentioned in subdivision (d) first and second shall be visible at a distance of at least two miles.

(e) Oyster dredgers and other vessels fishing with dredge nets shall carry and show the same lights as trawlers.

(f) Fishing vessels and fishing boats may at any time use a flare-up light in addition to the lights which they are by this article required to carry and show, and they may also use working lights.

(g) Every fishing vessel and every fishing boat under one hundred and fifty feet in length, when at anchor, shall exhibit a white light visible all around the horizon at a distance of at least one mile.

Every fishing vessel of one hundred and fifty feet in length or upward, when at anchor, shall exhibit a white light visible all around the horizon at a distance of at least one mile, and shall exhibit a second light as provided for vessels of such length by article eleven.

Should any such vessel, whether under one hundred and fifty feet in length or of one hundred and fifty feet in length or upward, be attached to a net or other fishing gear, she shall on the approach of other vessels show an additional white light at least three feet below the anchor light, and at a horizontal distance of at least five feet away from it in the direction of the net or gear.

(h) If a vessel or boat when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall in daytime haul down the day signal required by subdivision (k); at night show the light or lights prescribed for a vessel at anchor; and during fog, mist, falling snow, or heavy rainstorms make the signal prescribed for a vessel at anchor.

(See subdivision (d) and the last paragraph of article fifteen.)

(i) In fog, mist, falling snow, or heavy rain storms drift-net vessels attached to their nets, and vessels when trawling, dredging, or fishing with any kind of drag net, and vessels line fishing with their lines out, shall, if of twenty tons gross tonnage or upward, respectively, at intervals of not more than one minute make a blast; if steam vessels, with the whistle or siren, and if sailing vessels, with the fog-horn, each blast to be followed by ringing the bell. Fishing vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals; but if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

(k) All vessels or boats fishing with nets or lines or trawls, when under way, shall in daytime indicate their occupation to an approaching vessel by displaying a basket or other efficient signal where it can best be seen. If vessels or boats at anchor have their gear out, they shall, on the approach of other vessels, show the same signal on the side on which those vessels can pass.

The vessels required by this article to carry or show the lights hereinbefore specified shall not be obliged to carry the lights prescribed by article four (a) and the last paragraph of article eleven.

### LIGHTS FOR AN OVERTAKEN VESSEL.

ART. 10. A vessel which is being overtaken by another shall show from her stern to such last-mentioned vessel a white light or a flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side lights.

### ANCHOR LIGHTS.

ART. 11. A vessel under one hundred and fifty feet in length when at anchor shall carry forward, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light, in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of one hundred and fifty feet or upwards in length when at anchor shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, one such light, and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel aground in or near a fairway shall carry the above light or lights and the two red lights prescribed by article four (a).

### SPECIAL SIGNALS.

ART. 12. Every vessel may, if necessary in order to attract attention, in addition to the lights which she is by these rules required to carry, show a flare-up light or use any detonating signal that can not be mistaken for a distress signal.

### NAVAL LIGHTS AND RECOGNITION SIGNALS.

ART. 13. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by ship-owners, which have been authorized by their respective Governments, and duly registered and published.

### STEAM VESSEL UNDER SAIL BY DAY.

ART. 14. A steam vessel proceeding under sail only, but having her funnel up, shall carry in daytime, forward, where it can best be seen, one black ball or shape two feet in diameter.

## III.—SOUND SIGNALS FOR FOG, AND SO FORTH.

### PRELIMINARY.

ART. 15. All signals prescribed by this article for vessels under way shall be given:

First. By "steam vessels" on the whistle or siren.

Second. By "sailing vessels" and "vessels towed" on the fog horn.

The words "prolonged blast" used in this article shall mean a blast of from four to six seconds duration.

A steam vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn, to be sounded by mechanical means, and also with an efficient bell. In all cases where the rules require a bell to be used a drum may be substituted on board Turkish vessels, or a gong where such articles are used on board small seagoing vessels. A sailing vessel of twenty tons gross tonnage or upward shall be provided with a similar fog-horn and bell.

In fog, mist, falling snow, or heavy rain storms, whether by day or night, the signals described in this article shall be used as follows, namely:

### STEAM VESSEL UNDER WAY.

(a) A steam vessel having way upon her shall sound, at intervals of not more than two minutes, a prolonged blast.

(b) A steam vessel under way, but stopped, and having no way upon her, shall sound, at intervals of not more than two minutes, two prolonged blasts, with an interval of about one second between.

### SAIL VESSEL UNDER WAY.

(c) A sailing vessel under way shall sound, at intervals of not more than one minute, when on the starboard tack, one blast; when on the port tack, two blasts in succession, and when with the wind abaft the beam, three blasts in succession.

### VESSELS AT ANCHOR OR NOT UNDER WAY.

(d) A vessel when at anchor shall, at intervals of not more than one minute, ring the bell rapidly for about five seconds.

### VESSELS TOWING OR TOWED.

(e) A vessel when towing, a vessel employed in laying or in picking up a telegraph cable, and a vessel under way, which is unable to get out of the way of an approaching vessel through being not under command, or unable to maneuver as required by the rules, shall, instead of the signals prescribed in subdivisions (a) and (c) of this article, at intervals of not more than two minutes, sound three blasts in succession, namely: One prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

### SMALL SAILING VESSELS AND BOATS.

Sailing vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals, but, if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

### SPEED IN FOG.

ART. 16. Every vessel shall in fog, mist, falling snow, or heavy rain storms, go at a moderate speed, having careful regard to the existing circumstances and conditions.

A steam vessel, hearing, apparently forward of her beam, the fog signal of a vessel the position of which is not ascertained shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

### IV.—STEERING AND SAILING RULES.

### PRELIMINARY.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.

### SAILING VESSELS.

ART. 17. When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is closehauled.

(b) A vessel which is closehauled on the port tack shall keep out of the way of a vessel which is closehauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to the leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.

### STEAM VESSELS.

ART. 18. When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This article only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end on, or nearly end on to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own; and by night, to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course; or by night, to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

### TWO STEAM VESSELS CROSSING.

ART. 19. When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

### STEAM VESSEL SHALL KEEP OUT OF THE WAY OF SAILING VESSEL.

ART. 20. When a steam vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel.

### COURSE AND SPEED.

ART. 21. Where, by any of these rules, one of two vessels is to keep out of the way, the other shall keep her course and speed.

Note—When, in consequence of thick weather or other causes, such vessel finds herself so close that collision can not be avoided by the action of the giving-way vessel alone, she also shall take such actions as will best aid to avert collision. [See articles twenty-seven and twenty-nine.]

### CROSSING AHEAD.

**Art.** 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

### STEAM VESSEL SHALL SLACKEN SPEED OR STOP.

**Art.** 23. Every steam vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

### OVERTAKING VESSELS.

**Art.** 24. Notwithstanding anything contained in these rules, every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel, she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

### NARROW CHANNELS.

**Art.** 25. In narrow channels every steam vessel shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such vessel.

### RIGHT OF WAY OF FISHING VESSELS.

**Art.** 26. Sailing vessels under way shall keep out of the way of sailing vessels or boats fishing with nets or lines or trawls.

This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fairway used by vessels other than fishing vessels or boats.

### GENERAL PRUDENTIAL RULE.

ART. 27. In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

### SOUND SIGNALS FOR PASSING STEAMERS.

ART. 28. The words "short blast" used in this article shall mean a blast of about one second's duration.

When vessels are in sight of one another, a steam vessel under way, in taking any course authorized or required by these rules, shall indicate that course by the following signals on her whistle or siren, namely:

One short blast to mean, "I am directing my course to starboard."

Two short blasts to mean, "I am directing my course to port."

Three short blasts to mean, "My engines are going at full speed astern."

### PRECAUTION.

ART. 29. Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

ART. 30. [See page 166.]

### DISTRESS SIGNALS.

ART. 31. When a vessel is in distress and requires assistance from other vessels or from the shore, the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. The international code signal of distress indicated by N C.

Third. The distance signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. Flames on the vessel (as from a burning tar barrel, oil barrel, and so forth).

Third. Rockets or shells throwing stars of any color or description, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

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## Examples:

NORTHERN HEMISPHERE.—Storm track N. E. and the wind S. E. Then the ship is on the storm track and the STORM CARD gives the following directions:

If the wind changes to the southward, heave to on the starboard tack. If the wind changes to the eastward, run N. N. W. or heave to on the port tack.

SOUTHERN HEMISPHERE.—Storm track S. E. and the wind N. E. Then the ship is on the storm track and the STORM CARD gives the following directions:

If the wind changes to the northward, heave to on the port tack. If the wind changes to the eastward, run S. S. W. or heave to on the starboard tack.

If in either case the wind does not change, run on the course indicated on the proper card.

### WINDS.

The term *Variable* has been defined in its general sense, or as compared to the terms *Constant* and *Periodical.* But, in Navigation, it is used in a special sense, that is, in designating and recording certain winds in the columns of the Log-Book. It is often misapplied, by seamen, to denote an *unsteady* wind, which, during the period of observation, may have veered and hauled through several points. In such cases the direction of the wind should be averaged to the nearest whole point. The term *Variable* should not only be used to designate very light airs flying all round the compass.

It was remarked by Lord Bacon and other writers, both in Europe and America, that the wind more frequently veers with the sun's motion, or passes round the compass in the direction of N., N. E., E., S. E., S., S. W., W., and N. W., to N. This follows in consequence of the influence of the earth's rotation in changing the direction of the wind. Dové has the merit of having, from Hadley's principle, propounded the *law of rotation of the wind,* and proved that the whole system of atmospheric currents, the permanent, periodical, and variable winds, obey the influence of the earth's rotation.

An important characteristic of winds is their quality, being dry or humid, warm or cold, according to their direction, and the nature of the earth's surface over which they have passed. Thus, in the northern hemisphere southerly winds are warm and moist, while northerly winds are cold and dry; and in the southern hemisphere *vice versa.* In Europe westerly winds are moist and easterly winds are dry, while in North America northeasterly are cold and humid and northwesterly winds cold and dry.

## MISCELLANEOUS.

HOT WINDS OF DESERTS.—On the deserts of Africa and Arabia there sometimes prevails a wind extremely dry and intensely hot, which raises clouds of sand and transports it to a great distance. This wind is known in the desert of Africa and Western Asia as *Simoon* or *Simoun* (from the Arabic *samma,* signifying hot, poisonous, or anything disagreeable or dangerous), while in Egypt it is called *Khamsin* (Arabic for fifty), because it generally blows for 50 days, from the end of April to the time of the inundation of the Nile. This hot, dusty wind is felt in neighboring regions where it is known under different names. In Sicily, South Italy, and adjoining districts it is called the *Sirocco.* This wind is the plague of the Two Sicilies, and sometimes extends to the shores of the Black and Caspian Seas and to the steppes beyond the Volga. It is called the *Samiel* in Turkey, from its reputed poisonous qualities. The *Solano* of Spain is a southeast wind, which prevails at certain seasons in the plains of Mancha and Andalusia, particularly at Seville and Cadiz. This wind produces dizziness and heats the blood to an unusual degree. The *Harmattan* of Guinea and Senegambia belongs to the same class of winds. It is a periodical wind, blowing from the dry desert of Africa to the Atlantic, from latitude 15° north to latitude 1° south, during December, January, and February. It may be said of all these winds that their destructive effects on animal and vegetable life are due rather to their parching dryness, glow-heat, and choking dust than to any really poisonous qualities.

PECULIARITIES OF WINDS FROM MOUNTAINS.—The winds proceeding from mountains present many interesting phases, a few of which will be described. The *Pampero* is a wind which blows chiefly in the summer season from the Andes, across the pampas of Buenos Ayres to the sea coast. It is thus a northwest wind, or part of the anti-trade of the southern hemisphere. It is a dry wind, frequently darkening the sky with clouds of dust, drying up the vegetation of the pampas, and often extending to a considerable distance seaward. Some competent authorities assert that the dust which is brought to the shores of Southern Europe comes not from Africa but from South America. They arrived at this conclusion by making microscopic examinations of the sand or dust, in which were found certain organisms and dried infusoria which are known to exist only in South America.

This theory further states that the dust was elevated into the upper regions of the atmosphere, where it met a current from the southwest and was transported over 5,000 miles before it again fell to the earth.

PUNA WINDS.—To the eastward of Arequipa, in Peru, there is a barren table-land, between two great chains of the Andes, called the Puna or the Punos, which, for four months of the year is swept by cold, dry winds. These winds are part of the south trade-winds, which, after having crossed the lofty range of the Cordilleras, are cooled and parched to a degree that has perhaps no parallel in any other country in the world. The inhabitants, in traveling, find it necessary to protect their faces from the glare and heat of the day and from the intense cold of the night. The drying qualities of the Puna wind are so excessive that the bodies of dead animals exposed to it are very soon turned into mummies. Prescott states that it was in this district that the ancient inhabitants of Peru preserved their dead.

In the south of Europe north winds are notorious for their violence. The great differences of the temperature of the Alps, the Mediterranean, and Africa, explain them; and when the polar current, with high atmospheric pressure generally accompanying it, is descending at the same time over Europe, the effect is greatly heightened.

Of these winds the most noted is the *Bora.* This word seems to be a corruption of *Boreas,* though said to be derived from a Sclavonic term for "furious tempest." The Bora is greatly dreaded in the upper part of the Gulf of Venice, where it rushes down from the whole line of the Julian Alps with such irresistible fury that not only numbers of vessels are sacrificed but it ravages the shore also, being feared as much for the suddenness of its attack as for its violence. Entire districts are rendered nearly uninhabitable by the destructive effects of this wind on all vegetation. Its general direction is between north and northeast, and its most usual continuance about fifteen or twenty hours, with heavy squalls and terrible thunder, lightning, and rain at intervals. But the Bora most feared, and with justice, is that which blows in sudden gusts for three days, subsides, and then resumes its former force for three days more.

The *Mistral* (*maestral*) is the term applied by the country people to the northwest wind which sweeps from France down on the Gulf of Lyons. This wind is experienced in both summer and winter, though it is more violent and of longer duration in the latter season. In summer the mistral usually blows during clear weather and seldom lasts more than twenty-four hours, while in winter it often lasts for several days and is accompanied by heavy rains. As a rule this wind blows hardest during the day, decreasing toward sunset, showing the direct effect of change of temperature in producing wind; for, during the day, the difference of temperature between the cold air of the mountains and the warm air over the sea is much greater than at night. These same winds prevail in the Gulf of Genoa and with equal strength, only that here, from the trend of the coast, they become N. N. E. in the middle of the Gulf.

The terrific squalls experienced in the Straits of Magellan, called by the natives *Williwaws,* undoubtedly owe their suddenness and violence to the great height of the mountains in that region (which are covered with ice and snow all the year) and to the corresponding differences of temperature of the air at such great elevations and that at the surface of the water.

## PRACTICAL NOTES ON REVOLVING STORMS.

It is now generally conceded by all who have had opportunity for personal observation, and who have given sufficient attention to the subject of Ocean Storms, that the most severe gales met with at sea are what is commonly known as *Revolving Storms,* variously called by seamen HURRICANES, TYPHOONS, CYCLONES, &c., according to the locality in which they blow.

The distinctive characteristics of these storms are sufficiently marked to distinguish them from the ordinary straight-line gales that blow; and the following brief practical remarks are intended to assist and enable the Navigator who may not be familiar with the subject of revolving storms, to not only judge of the character of the coming gale, but also to take timely measures to avoid the dangerous part of it, either by heaving-to on the proper tack or by running away from it, as the case may be; and also, in particular cases where the track of the storm lies in the same direction as the ship's course, to take advantage of it and run along with it.

In the year 1831 Mr. William Redfield, of New York, after long and careful personal investigation and study of the subject, published a paper, in which he demonstrated that the gales on the American coast were whirlwinds and had a progressive or forward movement, traveling on curved tracks at a considerable rate, and were traceable from the West Indies along the coast of the United States, curving off to the eastward at some point between the Bermudas and the banks of Newfoundland.

Professor Dové. of Berlin, after investigating a number of heavy gales that had attracted the attention of scientific men in Germany about the same time, came to similar conclusions regarding the character of those gales.

In 1838 Lieutenant-Colonel Reid, of the Royal Engineers, published a valuable work on the law of storms, in which he agreed in all particulars with the views of Mr. Redfield, having verified by personal observation all his theory. From investigations of storms in the South Indian Ocean, Colonel Reid further proved that the storms in the southern hemisphere revolve in the opposite direction to those in the northern hemisphere.

THEORY OF STORMS.—Upon the above standard authorities, and upon the recorded experience of a great many seamen whose reports are confirmatory of the Redfield theory, is based the assumption that the currents of air within the limits of the storm disc move in concentric circles around a center of low pressure, or, in other words, that the direction of the wind at any point within the storm disc is tangent to a circle the center of which is the storm center, and lies 90° (eight points) to the right, or on the right hand in the northern hemisphere, and 90° (eight points) to the left, or on the left hand in the southern hemisphere, supposing the observer to be facing the winds, as will appear by inspection of the accompanying storm cards.

EXCEPTIONS TO THE THEORY.—It is not pretended here to assert that this theory is absolutely true, or that the rule has no exception. To the contrary, the same experience that proves the theory also goes to show that the winds within the storm disc may, from various causes, be diverted from the circular course to any direction between the tangent and the radius of the circle, toward the center.

1st. *Proximity of Land.*—The *proximity of land* may generally be expected to affect the course of the winds in that part of the storm disc either in contact with it or under the influence of it, and may also, if the course of the storm is such as to strike a high coast at a considerable angle, so distort the entire storm disc as to render it difficult to determine the locality of the center from the direction of the wind; but if it be remembered that the effect of land upon a storm will always be to flatten it in, and thus bring the center nearer to the shore than the direction of the wind according to the circular theory would indicate, the Navigator may, even in such a case, by taking into account the character of the land and its distance from the place of the ship, estimate sufficiently near the position of the center to take proper measures for avoiding it.

2d. *Local Disturbances.*—Temporarily, from *local disturbances* within the storm disc, for a full discussion of which the Navigator is referred to the standard works on storms, viz.: Piddington's Sailors' Hornbook, Reid on the Law of Storms, Dove's Law of Storms, &c.

STORM PROBLEM.—The *storm problem,* considered only in its relation to the safe navigation of a ship at sea, is very simple, and may be briefly summed up under the following heads, which contain all that is necessary for a practical solution of it:

1st. Ascertain the character of the storm and locate the center.

2d. Determine the position of the ship in the storm disc, or the semicircle of the storm in which the ship is situated.

3d. Ascertain approximately the direction in which the storm is moving.

4th. Decide what to do with the ship to escape the center, or take advantage of the fair winds, as the case may be.

To ascertain the character of the storm, consult the barometer and the general appearance of the weather.

### BAROMETER.

First.—The barometer generally indicates the approach of a storm by a restless oscillating motion of the mercury, caused by a disturbed condition of the atmosphere in the vicinity of a storm, and the consequent passage over it of atmospheric waves of different heights. These oscillations have been observed to vary from a just perceptible motion to 0.02 in.

Second.—The barometer often rises suddenly just on the border in front of a storm, by reason of the air banking up there, and therefore, if the clouds and general appearance of the weather indicate the approach of a storm, the rise in the barometer, if any occurs, is no guarantee that it will not come, but rather a sign that a severe storm is coming.. (The barometer will probably not rise much in front of a slowly moving storm.)

Third.—A very rapid fall of the barometer after fairly entering the storm disc may be regarded as evidence of a very violent storm of small diameter, and a gradual fall would indicate the contrary.

Fourth.—The following table, from Piddington's Sailors' Hornbook, page 252, may be of service in aiding the Navigator to decide how to act under peculiarly trying circumstances, where a risk has to be taken to save the ship, and when the question of distance from the center becomes the most important factor in the solution of the problem:

TABLE.

| Average fall of barometer per hour: | Distance in miles from center: |
|---|---|
| From 0.02 in to 0.06 in | From 250 to 150 |
| From 0.06 in to 0.08 in | From 150 to 100 |
| From 0.08 in to 0.12 in | From 100 to 80 |
| From 0.12 in to 0.15 in | From 80 to 50 |

APPEARANCE OF THE WEATHER.—The indications of the approach of a cyclone do not differ materially from those of the ordinary gale; but a few such, as a hard steel-gray sky, or having a greenish tint, a blood red or bright yellow sunset, a heavy swell unaccounted for in any other way, and a thick lurid appearance of the sky, may be regarded in connection with a general threatening appearance of the weather, and particularly with a restless state of the barometer, as significant signs of a more than ordinary gale, and, whether seen separately or together, ought not to be disregarded.

BEARING OF CENTER, NORTH LATITUDE.—Having reason to suppose, from the action of the barometer and from the general appearance of the weather, that a revolving storm is near at hand, determine at once the bearing of the center. To do this, look in the wind's eye.

Then, if the ship is in the north latitude, the center bears eight points to the right of the wind point, or on the right hand, because in the northern hemisphere the currents of air within the storm disc move from right to left; that is, from north to west to south, and over east to north, &c., left-handed (in nautical parlance, *against the sun*), or in the opposite direction to the hands of a watch, looking at its face; and hence, at the north point of the storm circle the wind is east and the center bears south; at the west point of the storm circle the wind is north and the center bears east, always 90° or eight points to the right of the wind point.

Bearing of Center, South Latitude.—But if in south latitude, the center bears eight points to the left of the wind point, or on the left hand, because in the southern hemisphere the currents of air within the storm disc move from left to right; that is, from north to east to south, and over west to north, &c., right-handled (*with the sun*), or in the same direction as the hands of a watch, looking at its face. Hence, at the north point of the storm circle the wind is west and the center bears south; at the east point of the storm circle the wind is north and the center bears west, &c., always 90° or eight points to the left of the wind point.

Semicircles of Storm Disc.—The storm disc is divided into two equal parts by the line of the axis of the storm track, and the portion lying on the right side of this line (looking in the direction of the storm track) is termed the ***right semicircle,*** while the other half, or that portion lying on the left of the line, is called the *left semicircle.*

In the right semicircle the change of wind will be to the right; that is, from north toward east, from east toward south, from south toward west, &c., and the first change of wind will therefore indicate that the ship is in the right semicircle. *Then put the ship on the starboard tack.*

In the left semicircle the change of wind will be to the left; that is, from north toward west, from west toward south, &c., which will in like manner indicate that the ship is in the left semicircle. *Then put the ship on the port tack.*

The rule for the determination of the semicircle and the tack to heave-to on applies equally to *all* parts of the world; and if it be remembered that the name of the semicircle, the direction of the change of the wind, and the tack to heave-to on, all three correspond to the same side of a given line, we may reduce all that is necessary to remember, in order to place the ship in a safe position in the storm disc, to six words. Doing which, we should have:

For Right Semicircle.
"Right".... (Semicircle).
"Right".... (Wind changes to the right).
"Starboard" (Tack to heave-to on).

For Left Semicircle,
"Left"..... (Semicircle).
"Left"..... (Wind changes to the left).
"Port"..... (Tack to heave-to on).

On the Storm Track Run Before the Wind.—A vessel directly on the track of the storm, or near it on either side would not experience any perceptible change of wind, but would have a falling barometer and rapidly-increasing severity of the weather, if in front of the storm; and a rising barometer, with a gradual moderation of the weather, if in rear of the storm center.

If the ship be put before the wind and steered in one direction for a few hours, she will, if the storm be a revolving storm, change the wind, and reveal by this change the semicircle of the storm into which she has run.

TO ASCERTAIN THE DIRECTION OF THE STORM TRACK BY INSPECTION.—In Piddington's Sailors' Hornbook, charts are found upon which are projected the tracks of a number of storms in the Atlantic and Indian Oceans and the China Seas, including the Bay of Bengal and a portion of the Pacific. An inspection of these charts will show that storms in particular localities generally travel in the same direction, and, ordinarily, the probable course of a storm may be found by inspection from one of these charts, the approximate position of the ship being known. But, as there is no absolute certainty that every storm will pass over the beaten track, no opportunity to verify the tracks on the charts or to ascertain by observation the approximate course of the storm should be neglected.

### *To Ascertain the Direction of the Storm by Observation*

The approximate direction of the storm track may be found by plotting the positions of the ship and center on two or more consecutive bearings, using an estimated distance on the first bearing, and keeping an accurate account of the ship's way during the interval between the bearings. It follows here, as a matter of course, that the greater the angle between the bearings used the better the results obtained by this method.

To obtain satisfactory results from any of the foregoing methods of observation the ship should be hove-to. Having determined the position of the ship in the storm disc, and the approximate direction of the storm's forward movement on its track, the Navigator may intelligently so dispose his vessel as to incur the minimum amount of danger or reap the maximum attainable advantage, as the case may be.

If it be necessary to distance the center or to run out of the storm disc, the following rules should be observed:

### NORTHERN HEMISPHERE.

RIGHT SEMICIRCLE.—Haul by the wind on the starboard tack and carry sail as long as possible; if obliged to heave-to, do so on starboard tack.

**Left Semicircle.**—Bring the wind on the starboard quarter. Note the direction of the ship's head and steer that course. If obliged to heave-to, do so on port tack.

### ON THE STORM TRACK.

**In front of the center.**—Square away and run before it. Note the course and keep it, and trim the yards when the wind draws on the starboard quarter. If, however, obliged to heave-to, do so on port tack.

**In rear of the center.**—Run out with wind on starboard quarter, or heave-to on starboard tack.

## SOUTHERN HEMISPHERE.

**Right Semicircle.**—Bring wind on the port quarter. Note the course and keep it. If obliged to heave-to, do so on starboard tack.

**Left Semicircle.**—Haul by the wind on the port tack. Carry sail as long as possible, and if obliged to heave-to, do so on port tack.

### ON THE STORM TRACK.

**In front of the center.**—Run before it. Note the course and keep it, and trim the yards as the wind gradually hauls on the port quarter. If obliged to heave-to, do so on the starboard tack.

**In rear of the center.**—Run out with the wind on port quarter, or heave-to on port tack.

A rise in the barometer, improvement of the weather, and a gradual abatement of the force of the wind, will result from the above maneuvers; and the ship should in each case be kept on her course until by these signs it is made evident that she is out of danger.

All the above maneuvers depends, of course, on sea-room and the ability to carry sail. If sail can not be carried or land interferes the ship should be hove-to on the starboard tack in the Right Semicircle, and on the port tack in the Left Semicircle, and never otherwise.

A vessel lying-to on the port tack in the left semicircle in the Northern Hemisphere, and on the starboard tack in the right semicircle in the Southern Hemisphere, lies with her head toward the storm center, but there is no danger in this; as hove-to she will not head-reach to any great extent, and will therefore not approach the center so as to endanger the safety of the ship. A vessel so disposed comes up to the sea with every shift of wind and will ride out the gale safely, whereas if she is on the opposite tack she is headed off by every shift of wind and will eventually bring the sea on the beam and quarter, in which position, even if she does not founder, she is certainly likely to receive serious damage from the sea.

A vessel finding herself in a favorable place in the storm circle may safely run along with the storm in the following positions:

### *To Profit by the Storm.*

### NORTHERN HEMISPHERE.

1st. In rear of center on the line of its axis. Wind on port beam.

2d. Anywhere in the right rear quadrant. Wind on port side abaft the beam.

3d. Abreast and to the right of the center. Wind aft.

### SOUTHERN HEMISPHERE.

1st. In rear of center on the line of its axis. Wind on starboard beam.

2d. Anywhere in the left rear quadrant. Wind on starboard side abaft the beam.

3d. Abreast and to the left of center. Wind aft.

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